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CRYSTALS AND SEMICONDUCTORS

SPECIFICS OF RADIATION DEFECT FORMATION IN HIGHLY PURE HIGH-RESISTIVITY SILICON MANUFACTURED BY VARIOUS TECHNOLOGIES

Baku DOKLADY AKADEMII NAUK AZERBAYDZHANSKOY SSR in Russian Vol 37, No 1, 1981
pp 28-32 manuscript received 27 Jun 80

ZAITOV, F. A., BAKHAR, L. I., IL'CHENKO, L. I., CHKUNINA, V. N. and ISAYEV, F. K.,
Azerbaijan State Medical Institute imeni Narimanov

[Abstract] Results are presented from neutron bombardment of single crystals of high-resistivity (at least 10^4 ohm·cm), high purity ($N_{O_2} < 10^{15}$ cm^{-3}) silicon grown by the floating zone method with various defect structures. Three types of specimens were studied. The concentration and mobility of holes were determined by measurement of the Hall effect on a standard installation using a variable AC magnetic field. Neutron bombardment at 300 K, neutron flux 10^{10}-10^{13} n/cm^2, results in a decrease in the concentration of holes, rather rapid at fluxes over $5\cdot10^{12}$ n/cm^2. The results indicate that the material contains volumetric defects which may yield certain levels in the forbidden band and strongly influence the mechanism of scattering of charge carriers. These microdefects are apparently related to the presence of metallic impurities and are second phase inclusions. Most of the specimens studied did not have these anomalies, indicating nonuniformity of distribution of these microscopic defects, possibly a result of the high rates of growth of the materials. Neutron bombardment creates radiation defects in these specimens comparable to the presence of growth microdefects, resulting in a smaller change in electrophysical parameters of specimens containing the deep level. The defects formed upon neutron bombardment are identical for all of the types of materials studied but the mechanisms of their formation differ and are determined by the initial status of the material.
[193-6508]

UDC 548

FLOATING ZONE CRYSTALLIZATION WITH LASER HEATING

Moscow ROST KRISTALLOV in Russian Vol 13, 1980 (signed to press 3 Jul 80)
pp 314-318

BAGDASAROV, Kh. S., D'YACHENKO, V. V., KEVORKOV, A. M. and KHOLOV, A., Institute of Crystallography of the USSR Academy of Sciences, Moscow

[Abstract] A water-cooled YAG-Nd^{3+} laser was employed as the heat source in a configuration using either one or two such lasers to heat samples for crystallization studies. The experiments used primarily the Y_2O_3-Al_2O_3 system; the major results were obtained with the crystallization of yttrium-aluminum garnet $Y_3Al_5O_{12}$. Two lasers with a total power of 250 to 300 watts CW melted the end face of a rod to a depth of 3 to 4 mm, where the rod was 7 to 8 mm in diameter. When a single crystal rod was used, this power could only melt a rod with a diameter of 4 to 5 mm. Various techniques of crystal growth were employed and are discussed briefly: Verneuil's method with a single laser; a feed rod methed using two lasers focused on the end face of the rod; a differential pulling technique; crystallization by changing the absorption factor of the material through the introduction of a volatile additive. Schematics of the experimental configurations are shown along with photogrphss of the YAG single crystals which were grown with the above methods. Laser-heated zone melting makes it possible to produce a complex zonal melt profile and carry the process out in any medium without employing mechanical movement of the starting materials; it expands the possibilities for floating zone crystallization of difficultly fusible oxides and allows for visual observation of the crystal growth itself. Figures 6, references 9: 3 Russian, 6 Western.
[117-8225]

UDC 548

MODERN METHODS OF MONITORING AND CONTROLLING CRYSTALLIZATION PROCESSES

Moscow ROST KRISTALLOV in Russian Vol 13, 1980 (signed to press 3 Jul 80)
pp 304-313

LUBE, E. L., Institute of Crystallography of the USSR Academy of Sciences, Moscow

[Abstract] Techniques of monitoring crystallization processes can be broken down into four groups according to the nature of the data sought: 1. Measurement of the applied power parameters: voltage, current, heater power, etc.; 2. Measurement of equipment parameters such as heater temperature, crucible temperature, rate of crystal lift and rotation, etc.; 3. Monitoring comprehensive heat and mass exchange parameters - the position and shape of the interphase boundary, surface tension and viscosity of the melt, mass and cross section of the crystal, solution concentration; 4. The determination of crystal characteristics: composition, structure, defects. This review article treats the efficacy of the use

of these parameters to control crystal growth. Specific attention is devoted to Czochralski's technique of monitoring the shape of the melt meniscus close to the growing crystal; TV methods of monitoring crystal diameters or meniscus cross sections based on the dependence of the amplitude and pulse width of a video signal on the brightness and dimensions of the observed crystal; optical pyrometry; techniques of monitoring floating-zone melting based on gamma ray absorption as well as measurement of the moment of viscous friction; a weighing method used in the hydrothermal synthesis of crystals to monitor mass exchange between the zone solution and zone growth in a horizontal autoclave as well as a video display technique for X-ray topographic imaging. The essential conclusion of the paper is that control efficiency can be improved using a large number of feedback channels for a variety of significant parameters. Figures 6, references 45: 21 Russian, 24 Western.
[117-8225]

UDC 548

GROWTH OF CRYSTALS OF SOME NEW IONIC CONDUCTORS AND THEIR PROPERTIES

Moscow ROST KRISTALLOV in Russian Vol 13, 1980 (signed to press 3 Jul 80)
pp 296-304

RABENAU, A., Solid State Research Institute of the Society imeni Max Planck, Stuttgart, FRG

[Abstract] A careful systematic study of ion transport is necessary to understand the nature of increased ionic conductivity, with special attention devoted to conductivity anisotropy, which in turn necessitates the use of high quality rather large single crystals. This paper analyzes the growth and behavior of copper telluride-halides, lithium nitride and beta-eucryptite, studied at the Max Planck Society Solid State Research Institute, Stuttgart. The Bridgman technique was used to grow CuTeBr crystals from a stoichiometric mixture of CuBr and Te. The details of the technique are discussed and the overall conductivity of CuTeBr is plotted as a function of temperature for frequencies of 1 MHz, 1 KHz and DC; the pseudobinary behavior of CuBr-Te systems is also analyzed. Single crystal plates 1 x 1 cm and larger could be cut from the grown material. Lithium nitride was obtained using Czochralski's method and the bulk ionic conductivity of Li_3N is plotted as a function of temperature for both AC and DC, for two different axial orientations of the applied electrical field. The details of the growth technology are described; samples with diameters up to 3 cm and lengths up to 5 cm were obtained. The experiments in growing beta-eucryptite (beta-$LiAlSiO_4$) crystals were performed with melt compositions of LiF-AlF_3 containing from 8 to 15 mol.% AlF_3 in a temperature range of 1,100 - 1,000 °C. The technique is discussed and it is noted that crystals with diameters of 2 to 8 mm were found embedded in a matrix of the finely crystalline eucryptite. The majority of the large crystals appeared turbid due to inclusions. The conductivity is plotted as a function of temperature for electrical fields applied perpendicularly and parallel to the "c" crystalline axis and the solubility of beta-$LiAlSiO_4$ in melts of various compositions is also plotted as a function of temperature. Figures 13, references 17: 1 Russian, 16 Western.
[117-8225]

PARTICULARS OF RADIATION DEFECT FORMATION IN ESPECIALLY PURE HIGH-RESISTIVITY SILICON PRODUCED BY VARIOUS TECHNIQUES

Baku DOKLADY AKADEMII NAUK AZERBAYDZHANSKOY SSR in Russian Vol 37, No 1, 1981 pp 28-32 manuscript received 27 Jun 80

ZAITOV, F. A., BAKHAR, L. I., IL'CHENKO, L. I., CHKUNINA, V. N. and ISAYEV, F. K., Azerbaijan State Medical Institute imeni Narimanov

[Abstract] The paper gives the results of neutron irradiation of single crystals of especially pure silicon (O_2 concentration less than 10^{15} cm^{-3}) with resistivity greater than 10^4 ohm·cm with various structural defects. Three kinds of specimens were studied: A-silicon with selective etching revealing a swirl pattern typical of A-cluster density of 10^9 cm^{-3} or less; dislocation material without A-clusters and with a dislocation density of less than 10^4 cm^{-1}; B-silicon made by an improved technique without structural defects. Hole concentration and mobility were measured by determination of the Hall effect. It was found that neutron bombardment at 300 K with fluxes of 10^{10}-10^{13} neutrons/cm^2 reduces the hole concentration rather rapidly for fluxes greater than $5 \cdot 10^{12}$ n/cm^2. The results of the studies show that defects formed upon neutron bombardment in high-resistivity silicon are identical for all three types of material, although the mechanisms of formation differ, being determined by the initial state of the material, and specifically by the presence of residual impurities and structural defects. Figures 3, references 7: 5 Russian, 2 Western.
[209-6610]

FLUID DYNAMICS

UDC 530.18

CYLINDRICAL AND SPHERICAL WAVES OF FINITE AMPLITUDE IN POORLY DISPERSIVE MEDIA

Novosibirsk ZHURNAL PRIKLADNOY MAKHANIKI I TEKHNICHESKOY FIZIKI in Russian
No 2(126), Mar-Apr 81 pp 78-85 manuscript received 13 Feb 80

DORFMAN, A. A., PELINOVSKIY, Ye. N. and STEPANYANTS, Yu. A., Leningrad, Gor'kiy

[Abstract] Efforts in recent years to generalize the Korteweg-de Vries equation to describe nonplanar waves with axial or central symmetry (nonlinear cylindrical and spherical waves in poorly dispersive media) have resulted in individual special case solutions which describe quasisteady-state solutons, which have been experimentally observed. A partial differential equation is written in this paper for a Korteweg-de Vries boundary value problem generalized for the case of motions with axial and central symmetry in dimensionless variables and solved through the substitution of variables to obtain some new approximate solutions which take into account the influence of losses in the medium. The first case treated is that where the low frequency dissipation is assumed to be zero; it is found that the amplitude of the wave falls off as a function of $r^{-5/6}$ in the cylindrical case and $r^{-4/3}$ in the spherical case. It is noted that the results apply only to a linearized Korteweg-de Vries equation, which is not always justified for the description of axially symmetric waves and the limitations of its applicability are discussed. The second case assumes that nonlinear effects at small distances from the surface boundary predominate over dispersive effects. A precise solution is possible in this case and an expression is written for the wave amplitude as a function of distance. The solutions are illustrated with the example of bora waves, where simple asymptotic formulas are found for the three possible types of such shallow sea waves. An experimental confirmation found in the literature is cited: 100 kg of TNT was detonated in a reservoir with a depth of about 50 cm; good agreement is noted. The final case takes both nonlinearities and dispersion into account, where the low frequency dissipation is neglected and axial symmetry is assumed. Deficiencies of such solutions in the literature are discussed and better approximation formulas are derived. The range of applicability of the proposed solution is estimated. Figures 6, references 16: 6 Russian, 10 Western. [213-8225]

UDC 53.082.61.533.16:532.13

DYNAMIC VISCOSITY AND THERMAL CONDUCTIVITY OF WATER IN THE CRITICAL REGION

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 19, No 2, Mar-Apr 81
pp 287-292 manuscript received 20 Feb 80

ALEKSANDROV, A. A. and MATVEYEV, A. B., Moscow Power Engineering Institute

[Abstract] Improved scaled fundamental equations are proposed for anomalous components of dynamic viscosity and thermal conductivity of water based on equations of state derived for the thermodynamic properties of water in direct proximity to the critical state. The analysis relies on the results of approximation of interacting modes and the theory of renorm-groups. It is shown that empirical formulas can be used for the function of isothermal compressibility and thermodynamic derivatives calculated without direct use of the exact equation of state in the vicinity of the critical point. A comparison of the calculated values of viscosity and thermal conductivity with experimental results shows satisfactory agreement. The formulas derived for viscosity and thermal conductivity were used to calculate the Prandtl number $Pr = \eta C_p/\lambda$ in the critical region. The specific heat C_p was calculated from the equation of state of a linear parametric model. Figures 4, references 16: 9 Russian, 7 Western.
[180-6610]

UDC 531.517

PATTERNS OF DEVELOPMENT OF TURBULENT JETS WITH NONUNIFORM INITIAL VELOCITY PROFILE

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 19, No 2, Mar-Apr 81
pp 339-343 manuscript received 14 Jan 80

LARYUSHKIN, M. A. and DVUYNISHNIKOV, V. A., Moscow Power Engineering Institute

[Abstract] Experimental research with combustion chambers in magnetohydrodynamic facilities has shown that the mean velocity distribution of the jet process may be very nonuniform at the output from the burner unit. Expressions given in the known literature are restructed to accounting for nonuniformity associated with the wall boundary layer where the velocity profile conforms to the 1/7 law. Since the pattern of mean velocity distribution in a magnetohydrodynamic jet process depends on specific conditions and the nonuniformity may range widely, the authors investigate the influence that the initial nonuniformity of the velocity profile has on the ejection properties of the jet and the characteristics of jet development. The analysis is based on experimental studies of free submerged axisymmetric jets with symmetrically nonuniform initial velocity profile, differing in the degree of initial nonuniformity. The working fluid was air escaping from cylindrical nozzles, and the velocity profile was set up by a system of screens of various permeabilities. The fields of the mean and pulsation values of the longitudinal component of velocity were determined as well as the averaged values of the total

and dynamic pressures in two mutually perpendicular radial cross sections. The results show the feasibility of mapping jet flow on the basis of turbulence intensity behavior along the jet exis. Nonuniformity of the mean velocity on the nozzle tip has a considerable effect on intensity of jet development. As this nonuniformity increases, there is a monotonic reduction in the intensity of increase in the width of the boundary layer lengthwise of the jet, and the velocity on the jet axis also falls monotonically. At the same time, ejection capacity shows extremem behavior as a function of the degree of nonuniformity, reaching a minimum at a certain value. The momentum of the jet and the ratio of mass to perimeter remain constant lengthwise, and are indepenecent of initial nonuniformity. Figures 3, references 4 Russian.
[180-6610]

UDC 532.542.2:536.1

HEATING WALLS OF A FLAT OR CIRCULAR CHANNEL UPON TRANSFER OF A HEAT PULSE BY FLUID FLOW

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 19, No 2, Mar-Apr 81
pp 344-351 manuscript received 19 Feb 80

BASKOV, V. B., PLATONOV, E. G. and SOKOLOV, G. A., Leningrad Technological Institute imeni Lensovet

[Abstract] In the heat tracer method of measuring fluid velocities in tubes, transport of the heat marker by the flow is determined by measuring the temperature of the outer surface of the channel wall. The results of experimental studies have shown that heating of the channel wall has a considerable effect on temperature distribution on the outer surface. To deal with this situation, the authors offer a new solution for the problem of determining wall temperature of a flat or circular channel upon transfer of a heat pulse by fluid flow with consideration of the thermal conductivity of the wall. The results of the analysis show that the hypothesis of inertial anisotropy can be used to account for the effect that thermal conductivity of the tube wall has on deformation of a heat marker. Figures 3, references 6 Russian.
[180-6610]

LASERS AND MASERS

UDC 621.378.678:535.37

DYED COPOLYMERS AS MATERIALS IN LASER TECHNOLOGY

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 45, No 4, Apr 81 pp 662-665

IVANOVA, T. F., VOTINOV, M. P., DOKUKINA, A. F., PITERKIN, B. D., SMIRNOVA, Z. A. and YEMEL'YANOVA, G. M., Leningrad Polytechnical Institute imeni M. I. Kalinin

[Abstract] Paper delivered at the Second All-Union Conference on Laser Optics, Leningrad, 4-8 Jan 1980. Dyed polymers currently being used in laser technology suffer from the disadvantage of low optical strength. The authors consider ways to improve the properties of these materials by synthesizing components more resistant to the action of coherent light and developing polymer-dye solid solutions with optical characteristics that meet predetermined specifications. Experiments were done with polymethyl methacrylate, polystyrene and their copolymers with comonomer content ranging from 0 to 100%. The purity of the monomers was checked by determining the boiling point, index of refraction, and optical absorption in the ultraviolet and infrared. The polymers were synthesized by radical polymerization without a synthesizer in argon at 60°C. Thiopyriloheptamethyne (I) and (II), indopentacarbocyanine 3955 and its analog (III) were the dyes used. The dyed specimens were films 50 ± 5 m thick. Studies were done on the absorption spectra of the dyes in the polymer matrices, factors that influence them, and the mutual relation between the spectroscopic characteristics and the phototropism and optical strength of phototropic polymers. Solid solutions of dyes (I), 3944 and (III) show good agreement with Lambert-Beer law. Dye (II) starts at a given concentration to show an abrupt rise in the short-wave absorption band intensity, and the concentration dependence of optical density at the maximum of the resonance band has the appearance of a curve with a maximum. This is detrimental to both phototropism and optical strength. The nature of the polymer has different effects on the position of maxima, and the width and intensity of absorption bands. Increasing the styrene content in the copolymer from 0 to 100% in the case of dyes (III) and 3955 shifts the resonance maximum by 0.025 μm toward the blue side. In the case of the thiopyriloheptamethyne dyes there is no change in the position of the resonance maximum regardless of copolymer composition. However, for dye (II), beginning at a certain concentration the intensity of the short-wave maximum exceeds the intensity of the resonance maximum for all dyed copolymers. For polystyrene dyed with (I), the absorption spectrum shows no resonance band, and an intense maximum appears at 0.72 m. This effect is reversible. Investigation

of the phototropism of the dyes with a nanosecond Q-switched neodymium laser showed curves with saturation for dyes in polymethyl methacrylate films and for copolymers of methyl methacrylate with styrene of no more than 30%. Curves with a maximum were observed for styrene content of 60-100%. The optical strength was higher for films dyed with (I), 3955 and (III) than for those dyed with (II). Figures 5, references 4 Russian.
[181-6610]

UDC 621.378.325

FREQUENCY TUNING AND STIMULATED EMISSION OF HIGHER HARMONICS IN FREE-ELECTRON LASERS WITH INTENSE PUMPING FIELD

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 4, Apr 81
pp 764-770 manuscript received 26 Mar 80, after revision 6 May 80

GINZBURG, N. S., Institute of Applied Physics, USSR Academy of Sciences, Gor'kiy

[Abstract] Until now the research on nonlinear theory of free-electron lasers has dealt mainly with comparatively weak pumping fields that transfer low oscillator amplitudes to the electrons on the scale of the emission wavelength, so that radiation is dipole in nature. In strong pumping fields where the dipole approximation no longer holds, the theory of spontaneous undulator radiation states that the electron emits frequencies $\omega_k = k\Omega/(1 - \beta_{\parallel} \cos \psi)$, corresponding to the higher harmonics of the frequency of electron oscillations (bounce frequencies) $\Omega = 2\pi v_{\parallel}/d$. Here $v_{\parallel} = \beta_{\parallel} c$ is the translational velocity of the electron, d is the period of the undulator, ψ is the angle between the direction of propagation of the radiation of a quantum and the translational velocity of the electron. In addition, increasing the pumping intensity leads to an increase in the amplitude of transverse oscillations, and accordingly to a reduction in the mean translational velocity of electrons. As a result, radiation frequency is a function of pumping field strength for a fixed number of the harmonic. The author studies these effects in application to induced radiation of relativistic electron fluxes in a free-electron laser. It is shown that efficiency decreases with increasing number of the harmonic as a consequence of narrowing of the band of negative reabsorption. An examination is made of the feasibility of controlling the frequency of a free-electron laser (relativistic ubitron) by varying the pumping field intensity. Figure 1, references 18: 14 Russian, 4 Western.
[199-6610]

UDC 621.378.325

PROPAGATION OF LIGHT UPON EXPLOSION OF AEROSOLS IN LASER BEAMS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 4, Apr 81 pp 776-781
manuscript received 4 Apr 80

ZEMLYANOV, A. A., KOLOSOV, V. V. and KUZIKOVSKIY, A. V., Institute of Optics of the Atmosphere, Tomsk Affiliate, Siberian Department, USSR Academy of Sciences

[Abstract] When intense optical emission propagates in a water aerosol, the water droplets are exploded in the radiation channel. The expanding explosion products act as a piston, compressing the ambient atmospheric gas. This increases the mean density of the gas in the channel, and hence there is an increase in the average permittivity. Shock waves that arise in the explosion cause random perturbations of the density of the atmospheric gas. In a previous paper the authors considered the influence of the average permittivity profile on conditions of propagation of a probing light beam in the resultant channel [V. V. Kolosov, A. V. Kuzikovskiy, ZHURNAL TEKHNICHESKOY FIZIKI, Vol 49, 1979, p 101]. In this paper an analysis is made of propagation with consideration of scattering by random perturbations of the density of the atmospheric gas. The influence of the products of explosion on the conditions of propagation is disregarded. The combined action of the regular and fluctuating components of the density perturbation is analyzed. It is shown that for a certain time interval there is an increase in intensity of the radiation in the channel over the intensity at the channel input. Figures 3, references 4 Russian.
[199-6610]

UDC 521.375.826:621.382

EFFECT OF CAVITY PARAMETERS ON INTERMODE SPACING OF A GaAs-AlGaAs HETEROJUNCTION LASER

Tallinn IZVESTIYA AKADEMII NAUK ESTONSKOY SSR: FIZIKA, MATEMATIKA in Russian
Vol 30, No 1, Jan-Mar 81 pp 22-28 manuscript received 3 Jul 80

RAMMO, I., VABSON, V. and HALLER, J., Institute of Physics, ESSR Academy of Sciences

[Abstract] The spectral distance $\Delta\lambda$ between adjacent lines in the emission spectrum of a semiconductor laser is given by the formula $\Delta\lambda = \lambda^2/2L\bar{n}$, where λ is wavelength, $\bar{n} = n - \lambda \frac{dn}{d\lambda}$ is the effective index of refraction, n is the index of refraction of the material filling the resonator, and L is the length of the resonator. In the case of heterojunction lasers, this formula is not directly applicable because a certain fraction of the radiation propagates in wide-band emitters, and therefore the intermode spacing depends not only on the index of refraction of the active medium, but also on the index of refraction of the emitters as well as on the thickness of the active layer. In this paper the authors determine the way that intermode spacing depends on the cavity parameters

of GaAs-AlGaAs heterojunction lasers. The analysis is based on a model of a three-layer dielectric waveguide in which the constant of propagation γ is determined for the TE mode by solving the transcentental equation

$$\tan QD = Q(\sqrt{1 - Q^2} + \sqrt{\eta - Q^2})/(Q^2 - \sqrt{(1 - Q^2)(\eta - Q^2)})$$

with respect to Q, where η characterizes the asymmetry of the waveguide, D is the normalized thickness of the waveguide, and Q is the internal transverse parameter that established the distribution of the electromagnetic field in the waveguide. The constant of propagation is then calculated at known Q from the formula

$$\gamma^2 = k^2(\varepsilon_2 - Q^2(\varepsilon_2 - \varepsilon_1)),$$

where k is the wave vector in free space, ε_2 is the dielectric constant of the active layer and ε_1 is the greater of the dielectric constants of the emitters. On this basis, the authors introduce the index of refraction $n^* = \gamma/k$ and the effective index of refraction $\bar{n}^* = n^* - \lambda \frac{dn}{d\lambda}$ for heterojunction lasers, corresponding to some hypothetical homogeneous medium in which radiation has the same constant of propagation as in the actual heterojunction laser. These characteristics make it more convenient to compare the laser parameters with those of the material used in making the laser. It is shown that the effective index of refraction of heterojunction lasers ranges from the value for the emitter material (which has the greater value) to the effective index of refraction of the material of the active layer as the thickness of the active layer is increased. The way that the effective index of refraction of heterojunction lasers depends on the thickness of the active layer is determined mainly by the parameter of optical limitation. Calculation shows nonmonotonic behavior of the effective index of refraction of heterojunction lasers as the upper limit is approached with increasing width of the active layer. Experimentally determined effective indices of refraction and intermode spacing for GaAs-AlGaAs heterojunction lasers agree with the theoretical calculations. Figures 8, references 9: 1 Western, 8 Russian. [179-6610]

UDC 535.375+621.373:535

EXCITATION OF SPONTANEOUS AND STIMULATED RAMAN SCATTERING BY A SEQUENCE OF GIANT PULSES

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 50, No 4, Apr 81 pp 632-634 manuscript received 14 Nov 80

KOROTKOV, P. A. and DMITRIK, G. N.

[Abstract] An investigation is made of spontaneous and stimulated Raman scattering simultaneously excited by a GOR-30 ruby laser with passive Q-switch (ethanol solution of cryptocyanine). A single pumping pulse stimulated laser emission of a series of giant pulses separated by time intervals of 50-100 μs with pulse energy of 1 J and pulse duration of 30 ns. The laser emission was focused into a cell filled with benzene. The signals from the resultant stimulated and spontaneous Raman scattering were oscillographically displayed. The spectrum of spontaneous Raman scattering of benzene showed signals on 607, 992, 1178 and

1586 cm^{-1}, while only the line at 992 cm^{-1} was observed in the stimulated Raman spectrum. Stimulated Raman scattering is observed only on the first giant pulse of a sequence over a power range of 3-30 mW, whereas the spontaneous Raman spectrum is excited equally well by all pulses in a series. The suppression of stimulated Raman scattering after the first pulse is attributed to heating due to conversion of the energy of optical phonons to thermal energy. The thermal effects are local in nature, and therefore do not appreciably influence spontaneous Raman scattering since this process is distributed throughout the channel of laser beam propagation with radius much greater than the radius of the high-temperature column in the medium. It is concluded that the development of stimulated and spontaneous Raman scattering processes is independent. Figure 1, references 8: 7 Russian, 1 Western. [201-6610]

UDC 621.373:535

TUNABLE SINGLE-FREQUENCY PULSED DYE LASER WITH DIFFRACTION GRATING

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 50, No 4, Apr 81 pp 744-749
manuscript received 15 Jan 80

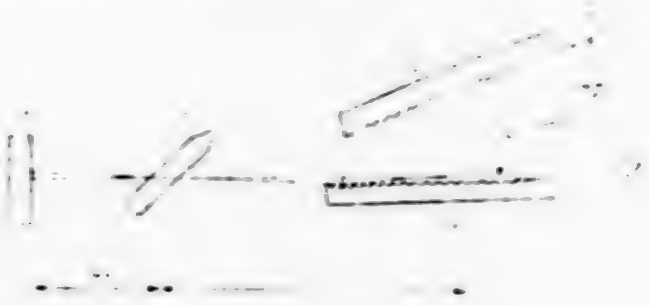
LEBEDEV, V. V. and PLYASULYA, V. M.

[Abstract] A tunable dye laser is proposed in which single-frequency stimulated emission is obtained with conventional reflecting diffraction gratings. A diagram of the laser cavity is shown in the figure. The actual optical cavity is formed by mirror M and diffraction grating G_2 operating in the autocollimation mode. Grating G_1 acts as a one-dimensional telescope and dispersing element, and also ensures coupling of radiation out of the cavity in the zero diffraction order at glancing incidence. It is shown that the resolution for the optimum cavity is given by the expression

$$\Delta\nu \sim \nu \frac{\sqrt{\lambda L}}{\frac{\cos\beta}{\cos\alpha}\left(\mathrm{tg}\,\beta + \mathrm{tg}\,\gamma + \frac{1}{\cos\gamma}\right)},$$

where α and β are the angles of incidence and diffraction respectively on grating G_1, and γ is the angle of diffraction on grating G_2. The angles α and β are expressed in terms of the lattice period, diffraction order and wavelength. The ratio $\frac{\cos\beta}{\cos\alpha}$ defines the effective magnification of grating telescope G_1. It can be seen that at large angles of incidence ($\alpha \to 90^\circ$) there is a sharp reduction in the width of the lasing spectrum. The case $\gamma = 0$ corresponds to substitution of a flat mirror for grating G_2. The use of the grating gives an appreciable additional reduction in spectral width as compared with a mirror at $\gamma > 40^\circ$. Experiments were done with a rhodamine-6G dye laser in a cavity with length L = 20 cm ($L_1 = L_2 = 20$ cm). Grating G_1 had 1200 lines/mm, and gave the first diffraction order at angle $\beta = 19^\circ$ for glancing angle $\alpha = 89^\circ$. The diffraction efficiency was about 3%. The coefficient of reflection from grating G_2 (600 lines/mm, fourth order, $\gamma = 42^\circ$) was 60%. Both gratings had a blaze angle

of 12.5° and lined section 5 cm wide. Dye cell C was set at the Brewster's angle and the thickness of the dye layer was 0.7 cm. Pumping was by a neodymium YAG laser with conversion to the second harmonic in a KDP crystal (532 nm). The laser was Q-switched with emission on a single transverse mode at a recurrence rate of 5 Hz with pulse duration of the harmonic equal to 13 ns and amplitude stability of 5%. Optimum beam diameter was 0.02 cm. The angle between the pumping beam and the axis of the cavity was 2-3°. Single-frequency lasing was obtained with a tunable range of 551-567 nm and pulse power of the order of 100 kW. The efficiency of the laser-amplifier system was 25%.



Figures 5, references 9: 8 Russian, 1 Western.
[201-6610]

UDC 621.373:535

DIFFRACTION SPLITTING OF OPPOSED WAVES OF A RING LASER WITH TWO-SCALE AMPLITUDE CORRECTOR

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 50, No 4, Apr 81 pp 750-754
manuscript received 20 Feb 80

BIRMAN, A. Ya., SAVUSHKIN, A. F. and TROPKIN, Ye. N.

[Abstract] Previous analysis of diffraction splitting of the frequencies of opposed waves of a ring laser has shown that such splitting is extremely critical to variation of the cavity parameters. Since this analysis was based on a square-wave model of amplitude correction of the field by one of the cavity elements, the authors now consider the extent to which this idealization of the form of amplitude correction is a source of the observed criticality. A two-scale amplitude corrector is considered that is described by a combination of probability integrals and in the limiting cases corresponds to gaussian and square-wave diaphragms. It is shown how the oscillations of diffraction splitting of frequencies with shifting of the diaphragm in the cavity, and also the extremum configurations of the cavity are related to the scale of smoothing of the edge of the diaphragm. An investigation is made of the way that frequency splitting depends on diffraction losses for diaphragms of different types. It is shown that diffraction splitting of frequencies increases with a reduction in the scale of smoothing at a fixed value of diffraction losses and this increase is intensified with weakening diffraction. Figures 6, References 2 Russian.

MODE-LOCKED YAG-Nd RING LASER WITH UNIDIRECTIONAL STIMULATED EMISSION

Leningrad ZHUR AL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 5, May 81
pp 1030-1032 manuscript received 28 Apr 80

GALKIN, S. L., GUSEV, A. A., PAKHOMOV, L. N. and SAMUSEV, K. B., Leningrad
Polytechnical Institute imeni M. I. Kalinin

[Abstract] The traveling-wave mode in ring lasers is achieved by two methods: by a "reversing" mirror, and by using an intracavity nonreciprocal device. This paper is devoted to realization of the traveling-wave mode in a mode-locked YAG-Nd ring laser by a method proposed by Tomov et al. [J. V. Tomov, R. Fedosejevs, McRichardson, OPT. COMMUN., Vol 21, 1977, p 327]. This method uses two intracavity Q-switches. In mode-locked operation, pulses are generated that can be considered short compared with the period of modulation T = L/C (where L is the length of the perimeter of the cavity). Analysis shows that if the shift of the switching signals corresponds to the time of travel of a light pulse between Q-switches, the pulse in one direction will pass the Q-switches at instants of zero losses, while losses in the other direction will be maximized for a distance between Q-switches of L/4, and will be zero for a distance L/2. Experimental verification of the proposed method gave unidirectional lasing with an intensity ratio in the two directions of at least 600:1, the intensity of the suppressed wave being determined mainly by backscattering. The width of the synchronized lasing spectrum reached 14.5 GHz, which corresponds to an emission pulse duration of about 70 ps. The phase-locked traveling-wave mode remained stable at an output power of 1 W for several hours without using automatic tuning systems. Figures 2, references 3: 1 Russian, 2 Western.
[204-6610]

UDC 621.378.3

INFLUENCE THAT ANISOTROPY OF ACTIVE ELEMENTS HAS ON POLARIZATION CHARACTERISTICS OF SOLID-STATE LASERS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 5, May 81 pp 806-811
manuscript received 15 Aug 79, after revision 8 Dec 80

GLAZKOV, V. N., ZHELTOV, G. I. and RUBANOV, A. S.

[Abstract] Control of the polarization characteristics of radiation of solid state lasers involves difficulties due primarily to thermal deformations of the active element that cause phase distortions of the optical cavity. Individual problems associated with the influence that thermo-optical distortions have on polarization characteristics of emission have been studied previously, and approximate relations have been derived for evaluating the degree of polarization of laser radiation for a cylindrical active element. In this paper a detailed examination is made of the distribution of states of polarization with respect to the radiating aperture of the cavity, and the way that this distribution depends on the amplitude

anisotropy of the cavity and the level of thermo-optical distortions of active elements in the form of a cylinder and a flat plate. It is shown that the form of the eigenstates of polarization may vary from linear to circular with azimuths of semimajor axes of the polarization ellipses from 0 to ±45° depending on the temperature difference between the center of the active element and its lateral surface. Principal results for cylindrical and rectangular active elements are given in the form of graphs. Figures 5, references 11 Russian.
[205-6610]

UDC 533.9:533.951.8

IMPROVING POWER AND EFFICIENCY WITH DYNAMIC SUPPRESSION OF IONIZATION INSTABILITY IN PLASMA

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 19, No 2, Mar-Apr 81
pp 399-406 manuscript received 11 Jan 80

VINOGRADOV, A. P. and FILINOV, V. S., Institute of High Temperatures, USSR Academy of Sciences

[Abstract] In MHD facilities under conditions where thermal ionization does not provide the necessary conductivity of the working fluid, a nonequilibrium plasma may be used with elevated electron temperature and correspondingly higher conductivity. The electron temperature may be raised above that of the heavy particles by heating with an induced electric field and taking steps to impede energy exchange upon collisions of the electrons with the heavy particles. However, the resultant ionization instability appreciably reduces the effective conductivity and effective Hall parameter of the plasma. The authors analyze a dynamic method of suppressing ionization instability by periodically changing the direction of the average current in the MHD channel to break up layers of inhomogeneity and re-establish the uniform state of the plasma. This is done by changing the type of circuit connection to the MHD facility from Faraday to Hall type and back. The output power and the electric and local polytropic efficiencies are studied as dependent on the load factor. Some of the particulars of the Faraday and Hall modes of operation of an MHD facility with developed and suppressed ionization instability are investigated. The possibilities for realizing the proposed suppression technique with semiconductor power devices are discussed. It is concluded that it would be realistic to use high-speed rf thyristors (TCh-100, TCh-125) capable of switching currents of the order of 100 A at voltages of the order of hundreds of volts with frequency up to 10^5 Hz. Figures 6, references 10: 8 Russian, 2 Western.
[180-6610]

UDC 538.3:530.145

SIGNIFICANCE OF FLUCTUATION OF A VACUUM UPON MOVEMENT OF AN ELECTRON IN THE MAGNETIC FIELD OF AN ACCELERATOR

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 24, No 3, Mar 81 pp 42-46 manuscript received 29 Oct 79, in final form 15 May 80

GRISHANIN, B. A. and YAROV, A. S., Moscow State University imeni M. V. Lomonosov

[Abstract] One of the most important factors determining the dimensions of the electron beam in accelerator and storage systems is the pumping of oscillations of the electrons by quantum fluctuations of synchrotron radiation. The quantum mechanism of pumping has been confirmed in a number of experiments, but experimental and theoretical data disagree. This apparently results primarily from variations in the parameters of actual installations from ideal ones. The question is whether this is a natural factor or whether there are finer quantum pumping mechanisms of a fundamental nature. This article demonstrates that in terms of axial oscillations the question can be answered just as exhaustively as the question of the mechanism of pumping of radial oscillations. The method of quasiclassical description of the relativistic particle outlined here is universal. Although the fluctuation excitation described and relationships of uncertainty are similar to the situation studied in the theory of relaxation of a quantum oscillator, the present situation does have its specific features, in that equilibrium is not a vacuum state, since the oscillating movement of a particle in an accelerator is not independent of the orbital movement. The connection is important for the formation of noise characteristics since it influences the noise characteristics through the phase coordinates of orbital motion. References 13: 5 Russian, 8 Western.
[194-6508]

UDC 533.561

LOW FREQUENCY RADIATION OF A CHARGE UPON MOVEMENT THROUGH A CIRCULAR ARC

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 24, No 3, Mar 81 pp 26-31 manuscript received 6 Nov 79

BAGROV, V. G., MOISEYEV, M. B., NIKITIN, M. M. and FEDOSOV, N. I., Scientific Research Institute of Nuclear Physics at Tomsk Polytechnical Institute imeni S. M. Kirov

[Abstract] It is demonstrated that radiation at "zero frequency" (where the radiation frequency approaches zero) is a nonzero function of the energy of a charged particle and as energy approaches infinity it diverges logarithmically. A study is made of the movement of an electron in a magnetic field along a circular arc with a central angle of 0 to 2π. The radiation of an ultrarelativistic electron at "zero frequency" is concentrated primarily in a cone of $\sim 2\gamma^{-1}$, the structure of the instantaneous angular distribution of the radiation differing significantly from the structure of the instantaneous synchrotron radiation. The full energy of radiation at the "zero frequency" is analyzed, as well as the spectral and angular characteristics of the radiation of the electron as it moves in a short magnet with arbitrary distribution of the magnetic field over the path of movement of the particle. The spectrum at high frequencies for smoothly changing or sine wave magnetic fields decreases as the fourth power of the radiation frequency, while for a cosine-homogeneous field it decreases as the square of frequency. The theoretical results of this work can be used to plan for the detection of "zero" radiation at the input or output of an electron beam from a magnetic field. Figures 6, References 8 Russian.
[194-6508]

INVESTIGATION OF ASYMMETRY OF EMISSION OF CHARGED PARTICLES IN REACTIONS OF CAPTURE OF POLARIZED THERMAL NEUTRONS BY ^{3}He AND ^{10}B NUCLEI

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 33, No 8, 20 Apr 81 pp 429-433 manuscript received 14 Mar 81

VESNA, V. A., YEGOROV, A. I., KOLOMENSKIY, E. A., PIROZHKOV, A. N., SMOTRITSKIY, L.M., Leningrad Institute of Nuclear Physics imeni B. P. Konstantinov, USSR Academy of Sciences, TITOV, N. A., Institute of Nuclear Research, USSR Academy of Sciences, and LOBASHEV, V. M., Leningrad Institute of Nuclear Physics, Institute of Nuclear Research

[Abstract] The paper is a continuation of research on effects of violation of spatial parity in nuclear reactions [PIS'MA V ZhETF, Vol 30, 1979, p 527; Vol 31, 1980, p 704]. In addition to reactions with ^{6}Li and ^{10}B, an investigation is made of the reaction $^3\mathrm{He}(n,p)^3\mathrm{H}$, which permits detailed theoretical calculations in contrast to many-nucleon systems of heavy nuclei. In addition to the P-odd correlation ($\vec{\sigma}$, p) an investigation was made of left-right assymmetry in the

direction of perpendicular to the spin and momentum of the captured particle of the form $\vec{\sigma}[p_n, p]$ where $\vec{\sigma}$, p_n, p are unit vectors in the direction of spin and momentum of the neutron, and the momentum of the light fragment. The research was done on a beam of polarized thermal neutrons of a VVR-M reactor with intensity of $6 \cdot 10^7$ neutrons/s. An integral method is used to determine the limits of P-odd asymmetry in the reaction $^{10}B(n, a_{0,1})^7Li$, $|a_0| < 1.6 \cdot 10^{-6}$ and $|a_1| < 3.8 \cdot 10^{-6}$, and in the reaction $^3He(n, p)^3H$, $|a| < 1.2 \cdot 10^{-6}$. Left-right asymmetry is observed in the reaction $^{10}B(n, a_0)^7Li$ with coefficient $a_{R-L} = (0.77 \pm 0.06) \cdot 10^{-6}$. Figures 2, references 5: 3 Russian, 2 Western.
[184-6610]

UDC 621.384.64

INVESTIGATION OF ELECTRON BEAM NOISES

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 4, Apr 81 pp 759-763 manuscript received 9 Aug 79, after revision 17 Nov 80

KRAMSKOY, G. D. and MONDRUS, I. N., Khar'kov Physicotechnical Institute, UkSSR Academy of Sciences

[Abstract] Noises in the beam-shaping system may have an appreciable effect on the development of transverse instability in electron linacs. Therefore the authors study beam noises as a basis for developing methods of suppressing them to reduce transverse instability and increase beam intensity. The characteristics used in the experimental investigation of the shaping system were the spectral densities of transverse deviations and the velocities of electron bunches at the injector output. It is shown that these noise characteristics can be measured by rectangular cavity resonators with E_{210} and H_{011} modes regardless of the critical current. The measurements are made close to the frequency of development of accelerator instability. Relations are found for the noise characteristics as a function of current at 0.1-1 A with various methods of regulation. Recommendations are made on reducing beam noise. Figures 3, references 8: 7 Russian, 1 Western.
[199-6610]

UDC 539.163

IDENTIFICATION OF NEW ISOTOPES IN REACTIONS WITH CHARGED PARTICLES ON THE U-150 ACCELERATOR

Alma-Ata IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR: SERIYA FIZIKO-MATEMATICHESKAYA in Russian No 2(99), Mar-Apr 81 pp 1-9 manuscript received 30 Nov 79, after revision 30 Jul 80

KOVRIGIN, O. D., Institute of Nuclear Physics, KaSSR Academy of Sciences

[Abstract] The author examines a method of identifying new isotopes produced in the beam of a low-energy accelerator--the U-150 isochronous cyclotron on the basis

of cross nuclear reactions, utilization of targets of different isotopic compositions, and analysis of excitation functions for various individual electromagnetic transitions. On this basis the method is expanded and extended to spectrometry of instantaneous radiation accompanying nuclear reactions. The method does not involve radiochemical or mass separation of the nuclear reaction products. Neutron-deficient isotopes Rh (A = 94), In (A = 104, 105), Sn (A = 106, 107) and Te (A=1 3) are identified. Electromagnetic transitions are identified by combined analysis of prompt and delayed spectra and the described technique of identifying new isotopes from the gamma rays of radioactive decay. The author determined the positions of maxima and the half-widths of the excitation function for some channels of nuclear reactions with protons, alpha particles and ^{3}He ions on targets of stable isotopes Sn (A= 112, 114), Cd (A = 106, 108) and Ru (A = 96, 98). Figures 5, references 19: 12 Russian, 7 Western.
[188-6610]

EXPERIMENTS ON COLLECTIVE-ION ACCELERATION BY A RELATIVISTIC ELECTRON CLOUD

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 80, No 4, Apr 81 pp 1391-1408 manuscript received 6 Sep 80

BURDAKOV, A. V., KOYDAN, V. S., ROGOZIN, A. I. and CHIKUNOV, V. V., Institute of Nuclear Physics, USSR Academy of Sciences

[Abstract] A systematic investigation is made of the method of collective-ion acceleration by an electron cloud (so-called gasdynamic collective-ion acceleration). A relativistic electron beam with current considerably exceeding the limiting vacuum current is generated in a high-current diode with massive cathode and thin-foil anode. The diode and vacuum drift chamber are placed in a longitudinal magnetic field. Most of the electrons injected into the chamber are reflected and begin to oscillate between the cathode and a "virtual cathode" that arises in the drift chamber behind the anode foil. As a result, a cloud of oscillating electrons is formed around the foil, producing a plasma layer that acts as an ion source by ionization of a nearby dielectric film. The electric field of the electron cloud pulls ions out of this plasma. These ions, compensating the space charge of the oscillating electrons, move along the chamber and are thus accelerated. In other words, a plasma is formed that consists of ions and oscillating relativistic electrons, and expands along the lines of force of the magnetic field. The electron gas "cools" and transfers its energy to the ions. Experiments were done with relativistic electron beam parameters as follows: maximum current 20 kA, maximum electron energy 1 MeV, pulse duration 50 ns, longitudinal magnetic field strength 20 kOe. Ion acceleration conditions are found that are optimum with respect to energy transfer from the electron beam to the ion flux. Acceleration efficiency under optimum conditions is about 50%. The total number of accelerated protons is $2 \cdot 10^{15}$ per pulse. Maximum proton current is 3.5 kA at current density of 400 A/cm^2. It is shown that most of the ions have energies of the order of 1 MeV or less, but some of them are accelerated to energies far exceeding the relativistic beam energies. Carbon ions, H_2^+ ions and hydrogen atoms are observed in the accelerated flux in addition to the protons. Figures 14, references 35: 15 Russian, 20 Western.
[187-6610]

RECOMBINATION EMISSION OF LIGHT BY MOLYBDENUM UPON BOMBARDMENT WITH SLOW ELECTRONS

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 80, No 4, Apr 81 pp 1514-1523 manuscript received 15 Aug 80

BORZYAK, P. G., GEGUZIN, I. I., DATSYUK, V. N., KONOVALOV, I. A., KULYUPIN, Yu. A. and PILIPCHAK, K. N., Institute of Physics, UkSSR Academy of Sciences

[Abstract] Visible emission that has been observed when metals interact with photons, x-rays, slow electrons, ions, atoms and molecules has been attributed at least partly to radiative recombination of nonequilibiium carriers that arise in the metal. In this paper the authors do experiments on the emission of light when molybdenum is bombarded with slow electrons, and examine the possibliity of explaining the characteristics of this emission by interband transitions. It is shown that the emission spectrum is formed mainly by direct interband recombination of electrons situated below the Fermi level with holes generated by the electron bombardment. The radiation yield is estimated at 10^{-9} - 10^{-11} photon per incident electron, which agrees reasonably well with the experimental value of 10^{-10} photon/electron at 100 eV. Figures 7, references 22: 12 Russian, 10 Western. [187-6610]

UDC 621.384.65

OPERATIONAL STABILITY OF VACUUM DIODES IN ACCELERATORS OF INTENSE RELATIVISTIC ELECTRON BEAMS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 5, May 81 pp 1005-1007 manuscript received 10 Sep 79

YEL'CHANINOV, A. S., ZAGULOV, F. Ya., KOROVIN, S. D. and MESYATS, G. A., Institute of High-Current Electronics, Siberian Department, USSR Academy of Sciences, Tomsk

[Abstract] The paper gives the results of investigation of the operating stability of a vaccum diode with explosive cathodes. The experiments were done on the "Sinus-4" accelerator [F. Ya. Zagulov et al., PRIBORY I TEKHNIKA EKSPERIMENTA, No 5, 1976, p 18]. The pulse generator of this accelerator has high stability of pulse parameters. The vacuum diode of magnetron type with anode radius of about 3 cm was placed in a strong magnetic field with intensity of about $5 \cdot 10^3$ oersteds. Graphite, copper and stainless steel were used as the cathode materials. The cathode was a hollow cylinder with radius of about 0.65 cm and wall thickness ranging from 0.1 to 2 mm. Pulse duration was about 30 ns with rise time of about 3 ns. Pulse recurrence rate was 50 Hz. Oscillograms are given for the total diode current and the voltage across the cathode for various materials and cathode geometries. It was found that operational stability depends on both the intensity of the electric field close to the cathode sufface and the cathode material. Instability increases with a reduction in the electric field on the cathode (increasing wall thickness). To improve operating stability, it

is necessary to increase the number of emission centers on the cathode surface, i. e. the average delay time of explosions of point emitters must be short compared to pulse duration, which can be achieved by appropriate modification of the geometry of the diode and the cathode, or in the case of a predetermined geometry by changing the cathode material. Figures 2, references 6: 4 Russian, 2 Western. [204-6610]

OPTICS AND SPECTROSCOPY

UDC 535

SPECIFICS OF THE REFRACTION OF GLANCING LIGHT RAYS FROM OPTICALLY LESS DENSE ABSORBING MEDIA

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 24, No 3, Mar 81 pp 57-60 manuscript received 28 Jun 79

TERENT'YEV, Yu. I., Institute of Optics of the Atmosphere, Siberian Affiliate, USSR Academy of Sciences

[Abstract] A study is made of the specifics of refraction of glancing rays from plates of absorbing optical glass in optically homogeneous fluids. The experiments were performed by measurement of light flux and beam intensity using photomultipliers installed at 107 mm from the leading edge of the plate and capable of movement along the horizontal axis of the glancing beam. In each experiment the light flux of the glancing and refracted beams was measured at various distances from the image of the slot to the refracting edge of the plate. The effect observed is described using the coefficient of increased refraction σ, which increases with increasing absorption, more strongly for purple glass than for neutral glass. Studies of the phenomenon are continuing. Figures 3, Reference 1 Russian.
[194-6508]

UDC 535.854

IKAP-2 INTERFEROMETER FOR TESTING THE QUALITY OF ASTRONOMICAL MIRRORS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 12, Dec 80 pp 17-20 manuscript received 12 Jul 79

PURYAYEV, D. T. and GORSHKOV, V. A.

[Abstract] The IKAP-2 interferometer has been specially developed to test the shape of the surface of the second main mirror of the BTA telescope. The interferometer contains a universal compensator which transforms the spherical wave front to a wave front of any desired shape, assuring normal incidence of the light rays at the surface being tested. Differences from a standard interferometer

include the fact that a special lens is used to assure that the wave front striking the compensator is strictly spherical; the compensator consists of three lenses separated by air gaps; a Kepler system is used in the illuminating branch of the interferometer. The method of operation with the interferometer is described. A diagram and photograph of the interferometer are presented, as well as an interferogram of the surface of the second main mirror of the BTA produced with the interferometer. The IKAP-2 interferometer has been used for manufacturing and certification testing of a 6 meter parabolic mirror, with interferograms analyzed both visually and by computer processing involving construction of a surface profile or topographic map. Figures 4, References 16: 11 Russian, 5 Western.
[191-6508]

UDC 539.3:522.2

CALCULATING TEMPERATURE DEFORMATIONS IN SECTORAL OPTICAL PARTS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 12, Dec 80 pp 8-9
manuscript received 12 Jan 79

SAITOV, I. Kh.

[Abstract] A numerical method is presented for calculation of the planar stress state of sectoral elements of mirrors modeled by structurally orthotropic plates of variable thickness, allowing determination of the displacement of any points on the operating surface upon application of a temperature field. No limitations are placed on the rule of change of rigidity or the temperature load. The algorithm for calculation has been implemented as an M-222 Algol computer program that generates data representing the deformation of the surface of a mirror and the redistribution of stresses relative to the initial state upon changes in temperature. The results are presented graphically, and indicate that ignoring the influence of temperature on the physical and mechanical characteristics of an optical element leads to significant error. Figures 4, references 3 Russian.
[191-6508]

UDC 681.7.06.055.778.38

INFLUENCE OF AIR TEMPERATURE GRADIENT ON ACCURACY OF TESTING LARGE MIRRORS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 12, Dec 80 pp 6-8
manuscript received 11 Feb 80

ZAKIROVA, R. G., LUKIN, A. V., RAFIKOV, R. A. and SAFEROVA, T. M.

[Abstract] A method is presented for estimating the influence of the temperature gradient of air in the control systems for large optical elements which is suitable for practically any distribution of temperature through the height of the room.

Estimation of the distortion caused by the temperature gradient was based on computer calculation of the path of rays through an optically heterogeneous medium represented as a series of horizontal layers, the number of which is determined by the required accuracy. Physical modeling of the temperature gradient of the air was undertaken under laboratory conditions and the experimental results produced using the model were compared with the calculated results. Interferograms produced by holographic interferometry in real time are presented. It is concluded that the influence of local slowly changing heterogeneities in the air medium may imitate local defects in the surface being tested and must therefore be considered and eliminated if possible. Figures 3, References 3 Russian.
[191-6508]

UDC 535.36:621.375.826

GAIN RATIO FOR REVERSED AND UNREVERSED WAVES IN STIMULATED SCATTERING OF LIGHT

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 257, No 5, 1981 pp 1116-1121
manuscript received 9 Jan 81

PILIPETSKIY, N. F., POPOVICHEV, V. I. and RAGUL'SKIY, V. V., Institute of Problems of Mechanics, USSR Academy of Sciences, Moscow

[Abstract] For stimulated scattering of light with spatially inhomogeneous intensity, the scattered wave that is reversed relative to the stimulating wave is sharply isolated in the scattered radiation due to higher amplification than that of the unreversed wave. According to theory, amplification of the process conforms to an exponential law in which the exponent in the function of the reversed wave is double the value for the unreversed wave. The authors describe experiments in which the efficiency of the amplification process as defined by the ratio of gains of the reversed and unreversed waves is studied with scattering in a light guide filled with carbon disulfide. The stimulating light from a single-mode ruby laser focused the image of a phase plate on the diode input. The light was concentrated in a solid angle of $1.9 \cdot 10^{-4}$ sr with approximate energy ranging from 1 to 40 mJ and pulse duration of 32 ns. The experimental results show that the gain ratio is in the range of $2.04 \pm 0.06 \leq g_{rev}/g_{unr} < 2.43 \pm 0.07$, where the upper value corresponds to the assumption of simultaneous excitation of the maximum number of modes in the light guide, and the lower value corresponds to the minimum number of modes. It is concluded that either we must revise the theory that predicts exponential gain with $g_{rev}/g_{unr} = 2$, or else assume that $\sim\sqrt{N_m}$ modes are stimulated in contradiction to the generally accepted notion of uniform distribution of the power of spontaneously scattered light over all modes of the light guide. This paper was presented at the Tenth All-Union Conference on Coherent and Nonlinear Optics, October, 1980. Figures 3, references 9: 6 Russian, 3 Western.
[198-6610]

UDC 535.2

SPATIAL FILTRATION OF AN OPTICAL SIGNAL BY A LAYER OF DISPERSED MEDIUM

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 50, No 4, Apr 81 pp 718-724
manuscript received 23 Apr 79, after revision 27 Aug 80

BABAK, E. V.

[Abstract] A method is proposed for determining the optical transfer function of a dispersed medium without analyzing the scattering function. The optical transfer function is used to determine the dimensions of particles of the dispersed layer. All results are given for incidence of a collimated light beam on the layer. It is assumed that each elementary event of scattering or transmission of light at a given point of the layer is a random process. The particles are taken as opaque and nearly spherical. It is assumed that the size distribution and concentration of the particles are known. The analysis is limited to the case where single scattering predominates. By taking the dispersed layer as homogeneous and isotropic, all properties of the random process can be determined by averaging with respect to the spatial coordinates of a single sample function. It is shown that under these conditions the autocorrelation function in the Wiener-Khintchine relation is the optical transfer function of the dispersed layer. The theory is confirmed by experimental results. Figures 2, references 11: 10 Russian, 1 Western.
[201-6610]

SLOW FLUCTUATIONS OF THE FIELD OF THE STOKES WAVE IN STIMULATED MANDELSTAM-BRILLOUIN SCATTERING WITH WIDE-BAND PUMPING

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 33, No 9, 5 May 81 pp 437-441 manuscript received 3 Mar 81

VOKHNIK, O. M. and ODINTSOV, V. I., Moscow State University imeni M. V. Lomonosov

[Abstract] Previous research has shown fluctuations of stimulated Mandelstam-Brillouin scattering with excitation by narrow-band laser radiation. These fluctuations are determined by the spectral width of the Stokes component $\Delta\omega_S$, and have a characteristic scale of $2\pi/\Delta\omega_S$. In the case of wide-band pumping, because of the great spectral width of the Stokes wave $\Delta\omega_S = \Delta\omega_L \gg \Delta\Omega$ ($\Delta\omega_L$ is the width of the pumping spectrum, $\Delta\omega$ is the width of the thermal scattering line), fluctuations should occur with short time $2\pi/\Delta\omega_S << 1/\Delta\Omega$. In this paper is is experimentally shown that in addition to these fast fluctuations of stimulated Mandelstam-Brillouin scattering in the coherent mode, there are also slow fluctuations with characteristic time $\tau > 2\pi/\Delta\Omega$ that is determined by the spectral width of the phonon wave. These same slow fluctuations arise when a Stokes pulse is amplified in an amplifier with wide-band pumping. Stimulated Mandelstam-Brillouin backscattering was excited in CCl_4, benzene and acetone by radiation from a single-mode ruby laser with spectral width of about 0.15 cm^{-1}.

The smooth laser pulse had a duration of 30 ns. The pumping radiation was focused by a lens (f = 15 cm) into a cell 22 cm long. The diameter of the light spot on the lens was about 3 mm. The experiments were done at a slight excess over the threshold of stimulated Mandelstam-Brillouin scattering, where the coefficient of conversion to the Stokes component was about 10%. The stimulated Mandelstam-Brillouin scattering in CCl_4 was close to single-mode, while in benzene and acetone there were several transverse modes. A theoretical interpretation is given. Figures 2, references 5 Russian.
[200-6610]

UDC 535.317.1

PARTICULARS OF RECORDING SPECKLE HOLOGRAMS IN MULTIMODE LASER EMISSION

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 50, No 5, May 81 pp 934-940
manuscript received 3 May 79, after revision 20 Nov 80

KLIMENKO, I. S.

[Abstract] There has been a recent upsurge of interest in methods of speckle interferometry. These techniques are based on photographic recording of images in diffusely scattered coherent radiation with modulation by the speckle structure of laser emission that acts as a holographic spatial carrier. The resultant holograms reconstruct the images of the initial diffusely scattering objects in the direction of the axis of an illuminating beam of arbitrary shape and spectral makeup. This paper gives the results of a theoretical and experimental study of the particulars of speckle holograms produced with exposure of diffusely scattering objects to the beam of a laser emitting in multimode operation, including in the case where there has been no preliminary diffuse scattering of the illuminating beam. It is shown that with such direct exposure, the reconstructed image is spatially modulated by the structure of transverse modes. However, the depth of the spatial modulation is relatively low, so that image quality can be considered acceptable. The diffraction efficiency within the limits of the region of the hologram corresponding to an arbitrary transverse mode is near maximum, and decreases slowly with an increase in the number of transverse modes. When the object is exposed through a diffuse scatterer, spatial modulation is eliminated in the reconstructed image. Although an increase in the number of emitted modes has no detrimental effect on homogeneity of illumination in the reconstructured image, such an increase does lead to a rapid falloff of diffraction efficiency of the speckle hologram and of any arbitrarily chosen section of the hologram. Figure 1, references 14: 10 Russian, 4 Western.
[202-6610]

OPTOELECTRONICS

UDC 681.327

REVERSIBLE INFORMATION STORAGE IN VO_2 FILMS

Novosibirsk AVTOMETRIYA in Russian No 6, Nov-Dec 80 pp 96-100

[Article by V. Ya. Bugrov, A. S. Ignat'yev, V. V. Kapayev, V. G. Mokerov and A. G. Petrova, Moscow]

[Text] The holographic characteristics of a recording medium based on vanadium dioxide films have been studied in Ref. 1-5.

Information recording in vanadium dioxide is achieved by a drastic change in the optical properties of the material upon the metal - dielectric phase transition (transition temperature ~67°C), and storage is realized through temperature hysteresis. This material is characterized by high resolution (up to 2000 l/mm), capability for nondestructive data readout, prolonged information storage, acceptable diffraction efficiency of holograms (~1%) and a large number of re-recording cycles ($>10^8$) [Ref. 1, 4].

The purpose of this research is to develop a large-capacity information store based on vanadium dioxide films for recording, long-term storage, readout and selective erasure of holograms, and to study the characteristics of this device.

An information store is proposed that is a matrix consisting of a 32 x 32 cell that is assembled from 16 bit lines. Each bit line includes 64 storage elements arranged in two rows (32 x 2). Fig. 1a-1c shows the topology and structure of these bit lines. Each cell is a sandwich of a quartz substrate (1) carrying films of the recording medium VO_2 (2), insulating oxide SiO_2 (3) and transparent resistive SnO_2 heaters (4) with contacts (5). A thin metallic layer (6) is introduced to increase the diffraction efficiency of the holograms during readout through interference effects [Ref. 4].

The storage mode (T_{st} corresponds to the region inside the hysteresis loop) in the described structure is achieved by Joule heat released in resistive heater (4) when current is passed through it. Selective erasure of the stored information is accomplished by varying the supply voltage of a given storage cell. The temperature of the VO_2 film beneath this heater decreases, and when a temperature T_{er} is reached that corresponds to the completion of the return branch of the hysteresis loop, previously stored information is erased.

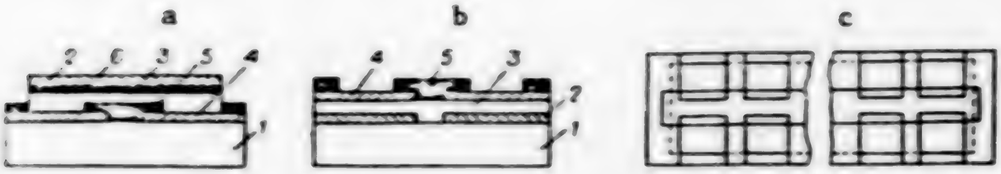


Fig. 1. Bit line structure of information store operating on reflection (a) and transmission (b); c--bit line topology

The size h of the memory cells and the distance l between them must be chosen such that on the one hand the information recording capacity is maximized, and on the other hand there is no mutual influence between adjacent cells, i. e. when the information in one of the cells is erased, the content of the adjacent cell must not change.

The numerical values of h and l were selected on the basis of calculation of the temperature field in the device. Since substrate thickness d (~0.02 cm) is much greater than the total thickness of the remaining layers of the structure (~1 μm), the temperature change through the thickness of these layers can be disregarded in calculations, and we can consider the temperature field in a single-layer parallelepiped. The action of the heaters is taken into consideration by introducing surface heat sources (at $z = 0$) of power P_0. We will assume that the placement of these sources on the surface (along the y-axis) is periodic with period $H = h + l$. In doing this, we disregard edge effects on the boundary of the store. Temperature distribution T(y) along the y-axis at $z = 0$ obtained from solution of the steady-state equation of heat conduction in a parallelepiped takes the following form:

$$T(y) - \Theta = \frac{P_0}{k}\frac{h}{H}d + \frac{2P_0}{\pi^2 k}H\sum_{n=1}^{\infty}\frac{1}{n^2}\,\mathrm{th}\,\frac{2\pi n d}{H}\sin\frac{\pi n d}{H}\cos\frac{2\pi n y}{H}, \tag{1}$$

where k is the coefficient of thermal conductivity of the substrate. Relation (1) is derived on the assumption that a constant temperature Θ is maintained on surface $z = d$ (condition of initial thermostatting), and the temperature in plane $z = 0$ coincides with the temperature of the VO_2 film.

To study the mutual influence of elements in the matrix it is sufficient to compare the temperature field at $z = 0$ in the following cases: a) all heaters engaged; b) every other heater engaged. The temperature distributions can be obtained from (1) by setting $H = H_1 = h + l$ in the first case, and $H = H_2 = 2h + 2l$ and $l' = h + 2l$ in the second case. The value of P_0 in case "a" is selected so that the temperature at $y = 0$ is equal to the information storage temperature.

Fig. 2 shows a family of curves T(y) for different h (the solid curves correspond to the case where all heaters are activated, and the broken curves correspond to activation of every other heater). In the calculation it was assumed that $d = 0.02$ cm, $T_{st} - \Theta = 45$°C, $l = 0.02$ cm. The curves in Fig. 2 give an idea of the mutual influence of the elements in a matrix, and the dimensions of the spot beneath the heater on which information can be recorded and stored. If an accuracy of storage temperature maintenance of 1°C is assigned, Fig. 2 shows that the size of the spot on which information can be stored for $h = 0.1$, 0.15, 0.20 and 0.25 cm is equal respectively to 0.03, 0.08, 0.13 and 0.18 cm. Thus even at $h = 0.15$ cm the useful area under the

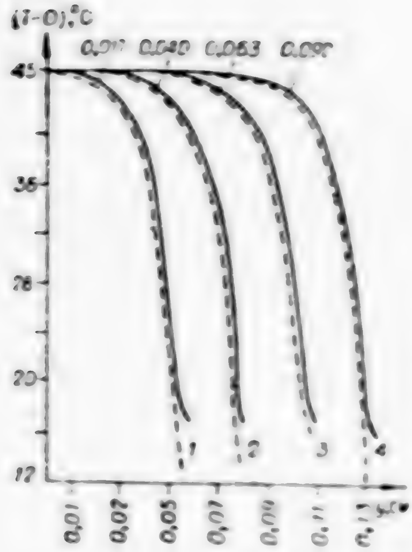


Fig. Temperature distribution over the surface of a storage cell for h (cm): 1--0.1, 2--0.15, 3--0.20, 4--0.25

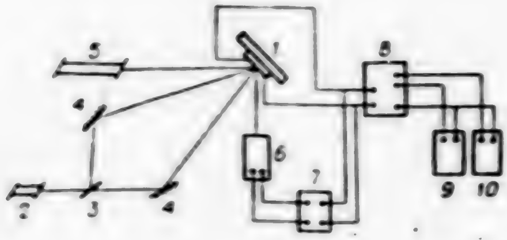


Fig. 2. Block diagram of facility for studying processes of recording, storage and readout of information in a store based on VO_2 films

heater is approximately equal to half the total area. The temperature under the disengaged heater permits reliable erasure of information in any cell for films with $T_{st} - T_{er} > 30$°C.

Let us point out that reducing the mutual influence of the elements by increasing l leads to a reduction in the useful area of the store. Under actual conditions the heat transfer from surface $z = d$ is somewhat poorer than under conditions of ideal thermostatting. Therefore the function T(y) will be flatter than the function shown in Fig. 2. Consequently the useful area under the heater where information can be stored increases.

Based on these considerations, we made an information store based on VO_2 films with dimensions of individual storage cells of 0.15×0.14 cm and distance between adjacent cells of 0.02 cm. The substrate was quartz 0.02 cm thick.

The vanadium dioxide film was applied by the method of reactive cathode sputtering. The thicknesses of films of VO_2, SnO_2, SiO_2 and Ni were 0.05-0.2, 0.1, 0.6-0.8 and 0.2 μm respectively.

The characteristics of the store were studied on the facility diagrammed on Fig. 3. The store (1) was placed on a thermostat in which the temperature could be varied over a wide range. Information was recorded by a pulsed LTIPCh-3 laser (2) having a frequency converter with $\lambda = 0.53$ μm. The duration of the recording pulses was ~20 ns. The optical system was made up of a beam splitter (3) and mirrors (4), enabling recording of the interference pattern of two plane beams in the memory cells. Information readout was by one of the recording beams or by the beam of an LG-36A He-Ne laser (5), which was also used in studying the temporal characteristics of the device, and investigation of the mutual influence of the storage cells. The light beam reflected from the surface of the vanadium dioxide film was incident on photomultiplier (6), the signal from this photomultiplier being sent to the input of an S1-17 oscilloscope (7). The G5-53 master oscillators (9, 10) and control circuit (8) were used to apply supply voltage to the storage cells. These components enabled selective information erasure and preparation of the memory cell for the next recording.

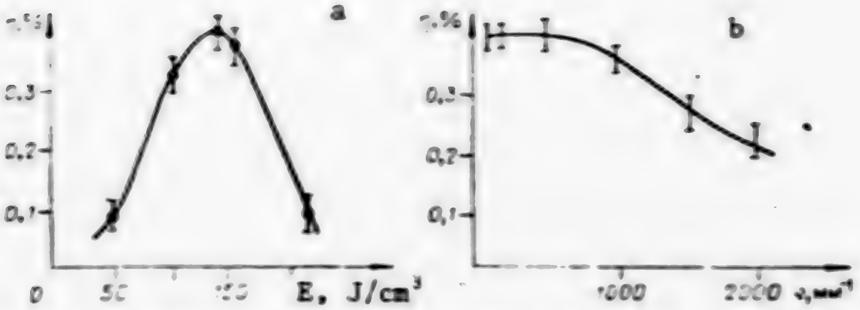


Fig. 4. Diffraction efficiency as a function of laser pulse energy for $\nu = 100$ mm^{-1} (a), and as a function of spatial frequency for $E = 150$ J/cm^3 (b)

The information storage temperature in the investigated VO_2 films was $T_{st} = 65°C$. At $\theta = 20°C$, the power released in the resistive heater ensuring realization of the storage mode in one storage cell was 16 W/cm^2. With increasing θ there is a linear reduction in P_{st}, and at $\theta = 40°C$ it is 9 W/cm^2.

The mutual influence of the storage cells in the store was studied in the following way ($\theta = 20°C$) All cells were put into the storage mode. A hologram was recorded in one of them by an isolated laser pulse, and the diffraction efficiency η was measured. Then the supply voltage of the other cells was cut off. Measurements showed practically no change in the value of η in the given cell. When the supply voltage to this cell was cut off (with the others switched on), the value of η fell to zero. This shows absence of mutual influence of the storage cells.

Determination of the useful area of a cell requires experimental data on the distribution of temperature along the surface of the cell T(x, y) when it is in the storage mode. Considering the sharp temperature dependence of reflectivity R of the VO_2 film in the vicinity of the phase transition, the distribution T(x, y) can be found from the relation R(x, y) which is determined by using a focused He-Ne-laser beam to scan the cell, and recording the reflected signal. For $\theta = 20°C$ the useful area of the cell at a storage temperature equal to $(T_{st} \pm 1)°C$ was ~70% of the area of the cell.

Curves for the diffraction efficiency η of holograms as a function of energy E in the recording laser pulse and the spatial frequency ν of the recorded hologram with readout by transmission on wavelength $\lambda = 0.63$ μm are shown in Fig. 4a and 4b. The general behavior of $\eta(E)$ and $\eta(\nu)$ upon readout by reflection is completely analogous to the curves shown in Fig. 4; however, the absolute value with readout by reflection depends on the properties of the material under the VO_2 film and on the thickness of the film, and reaches a value of ~1%. Let us note that these results agree well with theoretical relations for $\eta(E)$ and $\eta(\nu)$ found in Ref. 2 from calculation of the temperature field in a medium with consideration of phase transformations.

The duration τ_c of the complete working cycle of the storage cell is equal to the sum of the times of information recording τ_r, readout τ_{ro}, erasure, and preparation of the cell for the next recording τ_{pr}. Recording and readout of information are accomplished by pulsed lasers with pulse duration of the order of tens of nanoseconds, and therefore the duration of the total cycle depends mainly on the time of information erasure and the time of putting the cell into the storage mode.

Erasure time is determined by the thermophysical parameters of the system, the temperature of the thermostat and the temperature difference $T_{st} - T_{er}$ (i. e. by the width of the hysteresis loop of the vanadium dioxide film). To study the process of information erasure, an arbitrarily chosen storage cell was put into the information storage mode. Then the interference pattern of two plane beams was recorded in this cell by an isolated laser pulse. The ratio of the intensities in the beams was 1:1, and the spatial frequency was 100 mm^{-1}. The intensity of the light in the first diffraction order was recorded on a wavelength of $\lambda = 0.63$ μm. The change of this intensity after switching off the supply voltage in the given cell reflects the change of temperature of the VO_2 film. When the film reaches the information erasure temperature, the intensity of the diffracted light is equal to zero, and consequently the time of signal fall-off coincides with the time of information erasure τ_{er}.

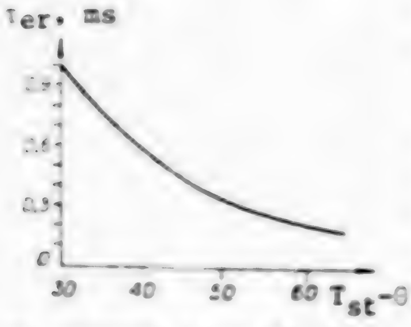


Fig. 5. Dependence of information erasure time on temperature difference $(T_{st}-\theta)$, $(T_{st} - T_{er} = 7°C)$

Fig. 5 shows the dependence of τ_{er} on the thermostat temperature as determined by the method described above. Storage temperature $T_{st} = 65°C$, information erasure temperature (temperature of completion of the return branch on the hysteresis loop) $T_{er} = 58°C$. Fig. 5 shows that by reducing the thermostat temperature we can get an an erasure time of the order of 0.1 ms. The value of τ_{er} can be reduced still further by using substrates of less thickness but with a higher coefficient of thermal conductivity.

It should be borne in mind that the reduction in τ_{er} with decreasing θ leads to an increase in the power required to maintain the storage state (P_{st}). Therefore the value of θ should be selected from compromise considerations.

If the storage cell is prepared by application of the supply voltage with amplitude corresponding to the storage mode at the instant when the VO_2 film reaches temperature T_{er}, then time τ_{pr} will be much longer than time τ_{er}. To increase the speed of the system, preparation for subsequent recording was done by applying a short pulse of power $P \gg P_{st}$ to the heater at the instant when the VO_2 film reached temperature T_{er}. After completion of this pulse, a voltage corresponding to the storage mode was applied to the heater. A time $\tau_{pr} \approx \tau_{er} = 0.1$ ms was obtained by varying the amplitude and duration of the afterpulse.

A store based on vanadium dioxide films has been used in a laboratory model of a holographic memory unit in a Hall circuit [Ref. 6]. The optical system of the device contained an electromechanical deflector, a beam splitter, a lens raster, and a system of objective lenses, and could record information on an area of about 1.2 mm^2. Readout of the holograms was on wavelengths $\lambda = 0.53$ and 0.63 μm. Research results showed a 4:1 signal-to-noise intensity ratio in a 32×32-bit image reconstructed from the holograms.

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CSO: 8344/1068-B

UDC 539.293.536.45

CALCULATION OF THE PROCESS OF RECORDING UNSTEADY HOLOGRAMS IN VANADIUM DIOXIDE FILMS

Novosibirsk AVTOMETRIYA in Russian No 5, Sep-Oct 80 pp 110-112

[Article by V. V. Kapayev, Moscow]

[Text] The method of unsteady (dynamic) holograms enables effective investigation of the characteristics of vanadium dioxide [Ref. 1, 2]. Moreover, as was pointed out in Ref. 2, self-diffraction of laser emission by optical inhomogeneities produced by this emission in VO_2 films can be used to determine the degree of coherence of pulsed lasers. This stimulated us to make a theoretical investigation of the process of recording unsteady holograms on vanadium dioxide films for a model previously adopted [Ref. 3], assuming a heating mechanism of photoinduced transition in the given substance as was done in the preceding paper [Ref. 3] for the mode of recording with subsequent storage (steady-state holograms).

The dynamic mode is realized if the temperature of the ambient medium G corresponds to a region below the temperature of completion of the reverse path on the hysteresis loop of physical properties of the film. In this case, the peculiarities of a phase transition in vanadium dioxide must be accounted for as fully as possible to calculate the temperature field with subsequent calculation of the diffraction efficiency η. Consideration of incomplete hysteresis loops leads to dependence of reflectivity R and heat capacity at a given point during the cooling phase on the maximum temperature reached at this point during the heating phase. Let us note that in Ref. 3 the value of G was taken as equal to T_0--the temperature of the beginning of the forward path on the hysteresis loop, and therefore the heat capacity at the given point was uniquely determined by temperature and by the sign of the time derivative of temperature $\dot{T}$ (i. e. by whether the temperature is increasing or decreasing at the given point).

Just as in Ref. 3, we will assume that the distribution function of the phase transition temperature in microsections has a rectangular shape ("width" of the transition δT), and the magnitude of temperature hysteresis ΔT is the same for all microsections. At $G < T_0 - \Delta T$ the heat capacity of the film can be recorded as follows

$$c(T, \dot{T}, T_{max}) = c_0 + (\lambda/\delta T)[\theta(T - T_1) - \theta(T - T_2)], \qquad (1)$$

where

$$T_1 = T_0 - \Delta T[1 - \theta(\dot{T})],$$

$$T_2 = \theta(\dot{T})[T_0 + \delta T] + [1 - \theta(\dot{T})][\min(T_{max}, T_0 + \delta T) - \Delta T],$$

$$\theta(x) = \begin{cases} 1 & \text{for } x > 0, \\ 0 & \text{for } x < 0. \end{cases}$$

T_{max} is the maximum temperature reached at the given point on the heating phase.

Upon recording of the simplest hologram, the temperature field in the film is determined from the equation

$$c\,(T, \dot{T}, T_{max})\,\frac{\partial T}{\partial t} = k\,\frac{\partial^2 T}{\partial x^2} - a(T - G) + \frac{F_0}{2\tau_{0.5}}\,\theta(-t + 2\tau_{0.5})\left(1 - \cos\frac{\pi t}{\tau_{0.5}}\right)\left(1 + \cos\frac{2\pi x}{d}\right) \tag{2}$$

with the following initial and boundary conditions

$$T(x, 0) = G; \quad \left.\frac{\partial T}{\partial x}\right|_{x=0} = \left.\frac{\partial T}{\partial x}\right|_{x=d} = 0. \tag{3}$$

Equation (2) was solved by a numerical method of finite differences. Additional complication of the computational scheme as compared with that used in Ref. 3 is due to the necessity of calculating the value of T_{max}, the corresponding complication in calculating heat capacity by formula (1) and consideration of incomplete hysteresis loops in calculation of R(x).

The distribution of reflectivity R(x) in the film was determined from the temperature field found from (2) and then, in complete analogy with Ref. 3, the intensities of light diffracted by the film were calculated for readout by reflection and transmission (the corresponding formulas are given in Ref. 3).

The values of constants appearing in equation (2) and also the values of the optical characteristics and thicknesses of the vanadium dioxide films were taken the same as in Ref. 3 in the calculations. The temperature G of the ambient medium was taken as equal to 20°C, which corresponds to the experimental situation considered in Ref. 1, 2. The time behavior of diffraction efficiency with readout by transmission is illustrated by Fig. 1a (during action of the recording laser pulse $t \leq 2\tau_{0.5}$) and Fig. 1b (after completion of the recording pulse). The behavior

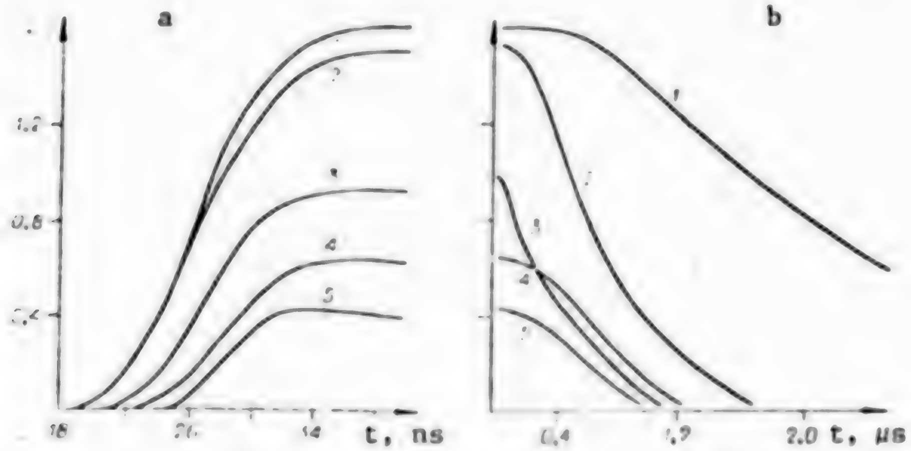


Fig. 1. Time behavior of diffraction efficiency:

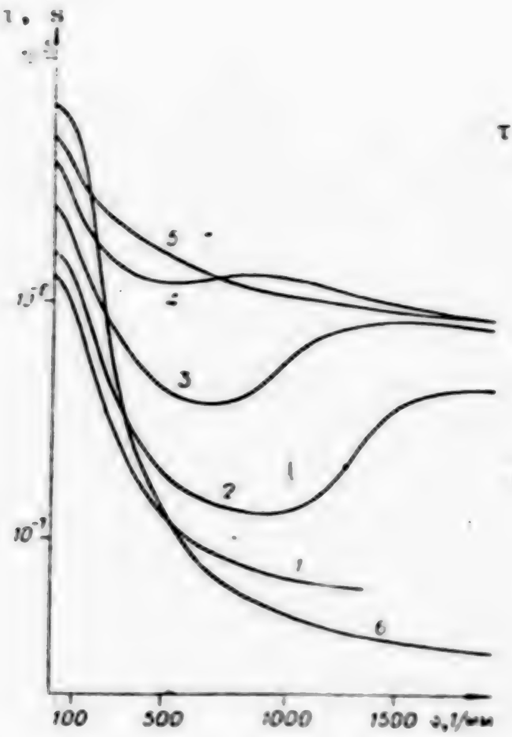
a--during the action of the recording pulse; b--after completion of the recording pulse. The value of ν for curves 1-5 is 1, 250, 1000, 1500 and 2000 1/mm respectively of $\eta(t)$ during readout by reflection is analogous to the curves of Fig. 1. However, the absolute value of η is an order of magnitude lower. Parameter α for all curves of Fig. 1 is equal to 10^6 W/(cm^2·deg), $F_0 = 200$ J/cm^3. As we can see from Fig. 1, three regions can be distinguished in the curve for $\eta(t)$.

At $0 < t < t_1$ the value of η is equal to zero (stage of delay). This stage corresponds to the fact that the maximum temperature in the film (at $x = 0$) remains below the temperature of the beginning of the forward path of the hysteresis loop (T_0), and therefore variations of temperature in the film that are caused by absorption of luminous energy do not cause changes in the optical characteristics of the material. The magnitude of the delay time t_1 depends on the energy in the recording pulse and, as can be seen from Fig. 1a, on the spatial frequency ν of the hologram being recorded. The latter is evidence that the diffusion of heat along the VO_2 film is appreciable even on the early stages of the process at fairly low values of ν.

At $t_1 < t < t_2$, an increase is observed in diffraction efficiency η, and at $t = t_2$ the value of η reaches a maximum. For low energies F_0 in the recording pulse the value of t_2 coincides with the time of completion of the recording pulse $t_p = 2\tau_{0.5}$. For fairly high energies ($F_0 \geqslant 300$ J/cm^3), $t_2 < t_p$. The reduction in η in this case for $t_2 < t < t_p$ can be attributed to the fact that the volume of sections of the film that are switched to the metallic state begins to exceed the volume of the semiconductor sections. The maximum value η_{max} for $F_0 \geqslant 300$ J/cm^3 corresponds to the fact that the volume of the semiconductor phase of the vanadium dioxide becomes equal to the volume of the metallic phase. The value of η_{max} in this case is on the order of two percent for readout by transmission.

After completion of the action of the recording pulse, the film cools freely to the ambient temperature G, the behavior of the diffraction efficiency being determined by the ratio of the rates of diffusion of heat along the film and in the substrate and by the presence of incomplete hysteresis loops with respect to optical properties in vanadium oxide. Let us define the relaxation time τ as the time of reduction in diffraction efficiency by a factor of e as compared with the maximum value η_{max} reached during the time of action of the recording pulse. Fig. 2 shows curves of the dependence of τ on the space frequency of the hologram $\nu = 1/d$ for different energies F_0 in the recording pulse. The behavior of $\tau(\nu)$ is determined appreciably by the value of F_0. At small and large F_0 the behavior of $\tau(\nu)$ at high spatial frequencies is close to an inverse square law (curves 1 and 6 on Fig. 2). At intermediate values of F_0 the behavior of $\tau(\nu)$ becomes more complicated. In some range of F_0, curves are observed with a minimum (curves 2-4 on Fig. 2). If the time of the fall-off in diffraction efficiency were determined by the fastest process in the system, as had been assumed in Ref. 1, the behavior of $\tau(\nu)$ would have had the appearance of curves 1 and 6 on Fig. 2 for all values of F_0. But consideration of incomplete hysteresis loops leads to the fact that the value of τ at high spatial frequencies where the fastest process is diffusion of heat along the film, is determined by the rate of diffusion in the substrate (in our description by the parameter α in equation (2)), i. e. by the slowest process over a rather broad range of F_0.

The parameter α is determined by the material of the substrate, the geometry and conditions of heat exchange of the entire system with the ambient medium and under actual conditions of an experiment may vary over a rather wide range. Fig. 3 shows



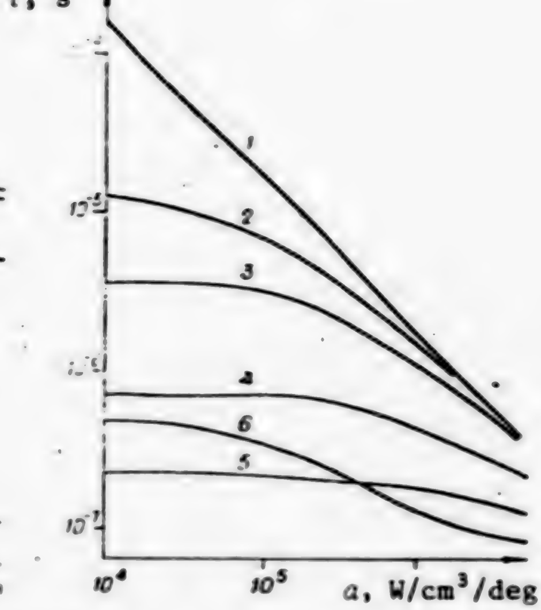


Fig. 2. Fall-off time (τ) of diffraction efficiency as a function of the spatial frequency (ν) of the hologram for $a = 10^6$ W/(cm³·deg) and values of F_0 (J/cm³) of: 1--130, 2--150, 3--200, 4--250, 5--300, 6--400

Fig. 3. Fall-off time (τ) of diffraction efficiency as a function of the coefficient of heat exchange of a film with the ambient medium (a) for $F_0 = 150$ J/cm³ and values of ν (1/mm) of: 1--1, 2--50, 3--100, 4--250, 5-500 6--1000

curves for the fall-off time of diffraction efficiency as a function of a for different values of ν and for $F_0 = 150$ J/cm³. At low ν (line 1 on Fig. 3) the value of τ is inversely proportional to a as in the case of cooling of a wide strip considered in Ref. 4. This is evidence that at such values of ν the diffusion of heat along the film is slight over the entire range that we have selected for a. For curves 2-6 the fall-off time at low a is practically independent of a. In this connection the value of τ is determined by the rate of diffusion of heat along the film. With increasing a there is an increase in the effectiveness of heat exchange of the film with the substrate, and upon attainment of some value $a = a_{cr}$ the heat exchange of the film with the substrate becomes more effective than heat exchange due to diffusion of heat along the film. The value of a_{cr} increases with increasing spatial frequency ν of the hologram being recorded. Straight line 1 is the asymptote for curves 2-6 at large ν. The curves on Fig. 3 are convenient for comparing the results of calculation with experimental data. From a comparison of the experimental values of the fall-off time of diffraction efficiency at low spatial frequencies with the calculated dependence of $\tau(a)$ we can determine the parameter a for specific conditions of an experiment. Then we can calculate the value of τ for arbitrary spatial frequencies even from the found value of a.

The author thanks L. S. Mednikova for assistance with the numerical calculations.

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CSO: 8344/1068-A

UDC 621.373:535

WIDE-BAND DYE LASER AS A SOURCE IN A SPECTRAL DATA TRANSMISSION SYSTEM

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 50, No 4, Apr 81 pp 625-627
manuscript received 10 Nov 80

DERYUGIN, L. N., DEMCHENKOV, V. P., PETRUS', A. A. and CHEKAN, A. V.

[Abstract] In a previous paper [L. N. Deryugin, A. V. Chekan, V. P. Demchenkov, RADIOTEKHNIKA I ELEKTRONIKA, No 10, 1979, p 2014] the authors described a method of transmitting a line of an optical image over an individual fiber by using spectral devices. In this technique the spectrum of a wide-band light source is modulated in accordance with optical transmission of a line of the image so that a certain frequency band is put into one-to-one correspondence with each element of the image. Modulation is accomplished by placing a film with the image or a system of modulators in the spectral plane of a spectrum analyzer. A second identical spectrum analyzer with direction of dispersion opposite to the first retransforms the spectrum into a beam like the input beam only with modulated spectral distribution of intensities. This beam can then be transmitted through air or over a single-fiber communication line to the reception spectrum analyzer. In this paper a spectral source is proposed that meets the requirements of the data transmission method in this system: a wide-band dye laser operating on a single transverse mode and a set of longitudinal modes. All the radiation from such a laser can be transmitted through a spectrum analyzer with normal input slit, realizing the maximum resolution of the device. Since the output flux of the transmitting system has laser divergence, vacuum or air lines can be used as well as simple matching to an isolated fiber optics line. A dye laser emitting in the green region of the spectrum with bandwidth of more than 100 Å was used in experiments to verify the proposed method. The output beam after modulation was coupled into a 20 μm fiber with length of 1.5 m. The results show that about 100 channels or image elements can be reliably accommodated in a 100 Å bandwidth. Thus it should be possible to use the proposed technique for multichannel data transmission systems with frequency separation of channels. Figures 2, references 4 Russian.
[201-6610]

PLASMA PHYSICS

UDC 533.9.01

KINETIC THEORY OF A RELATIVISTIC PLASMA

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 24, No 3, Mar 81 pp 78=82 manuscript received 27 Dec 79

NAUMOV, N. D., Moscow State University imeni M. V. Lomonosov

[Abstract] The basis of the statistical description of collective processes in a plasma is the Bogolyubov chain of equations. Analysis of a relativistic plasma based on the kinetic theory of Bogolyubov is important today due to the intensive radiation of current-day relativistic systems of charged particles such as electron beams and rings, as well as the experimental achievement of rather high temperature plasmas. The method is applied to a system consisting of several types of identical particles, looked upon as a system consisting of the same number of coulombs of charge and an infinite denumerable set of uncoupled oscillators, the number of oscillators for each frequency in the expansion being equal to the number of charged particles. Equations are derived for a relativistic plasma and a correlation function which generates a Belyayev-Budker collision integral. References 15: 14 Russian, 1 Western.
[194-6508]

UDC 533.915

INFLUENCE OF THE CATHODE LAYER ON THE CURRENT-VOLTAGE CURVE OF A DISCHARGE EXCITED BY AN ELECTRON BEAM

Novosibirsk ZHURNAL PRIKLADNOY MAKHANIKI I TEKHNICHESKOY FIZIKI in Russian No 2(126), Mar-Apr 81 pp 37-43 manuscript received 22 Jan 80

ORISHICH, A. M., PONOMARENKO, A. G. and SNYTNIKOV, V. N., Novosibirsk

[Abstract] A volume discharge is triggered in nitrogen containing less than 0.2% impurities in the chamber of an electron-beam controlled CO_2 laser, where the gas is ionized by an electron beam with an average energy of 120 KeV. The spacing between the electrodes was 3.7 cm and the energy source for the discharge was a KMK-50-4 capacitor bank with a capacitance of 30 microfarads and a maximum voltage of 50 KV. A two-wavelength Mach-Zehnder (0.63 and 10.6 micrometers)

interferometer measured the electron concentration, n; the plasma was probed by the interferometer along the maximum dimension of 100 cm in the center of the discharge gap. Special measurements showed that the values of n are constant within 10% along the direction of current flow. The energy source was connected to the discharge gap 2 microseconds prior to the actuation of the electron accelerator. An equation is derived for the discharge current following the electron beam cutoff. The behavior of the discharge following the disconnection of the ionizer is quantitatively and qualitatively described in considerable detail. The cathode potential drop is determined in the absence of the external ionizer in the high power volume discharge at pressures of from 0.25 to 1.0 atm in a range of $j_k/p^2 = 10^{-7}$ to 10^{-5} A/cm$^2 \cdot$mm Hg^2 (j_k is the discharge current density at the cathode). The possibility of substantially reducing the cathode potential drop is experimentally demonstrated for the case of external ionization, which is apparently attained by the intense ionization of the gas in the cathode layer by secondary electrons produced with the interaction of the high energy beam and the electrode surface. Figures 5, references 14: 13 Russian, 1 Western.
[213-8225]

PROPAGATION AND FOCUSING OF AN INTENSE ELECTRON BEAM IN DIELECTRIC CHANNELS

Moscow FIZIKA PLAZMY in Russian Vol 7, No 2, Mar-Apr 81 pp 267-275
manuscript received 18 Feb 80

AGAFONOV, A. V., AYRAPETOV, A. Sh., KOLOMENSKIY, A. A., KRASTELEV, Ye. G., LEBEDEV, A. N. and YABLOKOV, B. N., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] Effective electron beam transport is important for research on controlled fusion with inertial containment and for microwave generators. Intense electron beams can be transported to considerable distances with containment by magnetic fields or with neutralization of self-fields in a neutral gas or prepared plasma. A recent development is beam transport in dielectric channels in vacuum. The authors give the results of experimental and theoretical research on transport and focusing of 350-800 keV electron beams at currents up to 100 kA in such channels of cylindrical and tapered configuration. An analysis of equilibrium states of intense electron beams propagating in vacuum channels with dielectric walls shows that the diameter of the injected beam at a given current should be close to the equilibrium value, and the angle of injection should be matched to the angle of taper of the dielectric channel. Although theoretical analysis shows no limit on beam current for transport by this method, experimental studies reveal that the beam fills a small-diameter channel completely, and a further reduction in diameter does not result in a corresponding increase in beam current density. It is shown that the limiting factor for focusing of electron beams in a tapered channel is the emissivity of the plasma near the channel wall. Figures 10, references 5: 3 Russian, 2 Western.
[182-6610]

UDC 533.9.082.5

INFLUENCE OF METASTABLE STATES ON THE DEVELOPMENT OF A PULSED DISCHARGE IN HELIUM

Moscow FIZIKA PLAZMY in Russian Vol 7, No 2, Mar-Apr 81 pp 296 302
manuscript received 20 May 80

VOLKOVA, L. M., DEVYATOV, A. M., SHIBKOV, V. M. and SHIBKOVA, L. V., Moscow State University imeni M. V. Lomonosov

[Abstract] An investigation is made of a discharge in helium under conditions of pulsed modulation of the discharge current in a tube 3 cm in diameter with 20 cm between electrodes. Discharge currents ranged from 30 to 400 mA, and pressures were varied from 0.1 to 1.0 mm Hg. Pulse shape was square with duration of 1 ms, rise time of 1 μs and fall time of 3-5 μs. An S8-11 oscilloscope was used to register the discharge current pulse, the voltage across the discharge tube, the electric field strength, the probe characteristic and the plasma luminescence. The electron energy distribution function and time behavior of concentration of metastable helium atoms were determined. The temperature dependence of the coefficient of diffusion of metastable helium atoms in state 2^3S is derived, and it is shown that the shape of the discharge current pulse and luminescence pulse depends on the pulse recurrence rate. This is attributed to the influence that metastable helium atoms remaining after the pulse have on the development of the discharge in the following pulse. Figures 7, references 14: 11 Russian, 3 Western.
[182-6610]

UDC 621.278.325

INVESTIGATION OF NATURAL RADIATION OF A PLASMA FORMED IN AIR UNDER THE EFFECT OF LASER PULSES WITH $\lambda = 10.6$ μm

Moscow FIZIKA PLAZMY in Russian Vol 7, No 2, Mar-Apr 81 pp 350-364
manuscript received 24 Jul 80

DANILYCHEV, V. A., ZVORYKIN, V. D., KHOLIN, I. V. and CHUGUNOV, A. Yu., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] An investigation is made of the spectral, brightness and energy characteristics of natural radiation of a plane layer of plasma formed under the action of intense (about 1 GW) pulses of laser radiation with $\lambda = 10.6$ μm on various solids in air, and a comparison is made with the results of gasdynamic measurements. The studies were done at flux densities of $5 \cdot 10^6 - 10^8$ W/cm^2 and gas pressures of 0.1-760 mm Hg. It is shown that at pressures of the order of 2-5 mm Hg the radiative properties of the plasma are determined by the laser radiation absorption wave that arises in the plasma. The maximum brightness temperature of 50,000 K ($\lambda = 400 \pm 20$ nm) was reached at a pressure of 25 mm Hg. The emission spectrum differed considerably from equilibrium, and contained mainly lines

NII, OII and NIII. The total energy emitted by the plasma in the range of 320-2600 nm in a solid angle of 4π sr reached 2.3% of the laser pulse energy. Figures 8, references 27: 17 Russian, 10 Western.
[182-6610]

UDC 535.214

INVESTIGATION OF THE RECOIL MOMENTUM AND ACCELERATION INDUCED BY LASER EMISSION OF VARIOUS DURATIONS. USE OF SLIDING FOCUSING IN ACCELERATION

Moscow FIZIKA PLAZMY in Russian Vol 7, No 2, Mar-Apr 81 pp 255-266
manuscript received 6 May 80

ASKAR'YAN, G. A. and MANZON, B. M., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The authors study the impulse momentum of the target and the velocity of particles when the giant pulse from a neodymium laser with duration ranging from 50 ns to 5 μs and energy of 30-140 J acts on a massive steel ball. It is shown that the results of experiments on measuring recoil moments of massive bodies exposed to laser emission can be used to predict the attainable velocities of small macroparticles and to develop methods of increasing the efficiency of acceleration. When the duration of a giant laser pulse is increased without charging the energy, the recoil moments of solids and the velocities of microparticles increase in proportion to $\tau^{0.22}$, while the pressure on them decreases as $\tau^{-0.8}$, leading to more efficient and smoother acceleration. When the laser radiation is focused in a deep channel on the surface of the target, or the particle is put into a channel, there is a more appreciable increase in the recoil momentum with a short giant pulse, or with a series of short pulses such that the plasma has time to disperse in the intervals between pulses. Comparison of experiment with theory shows good agreement with a steady-state model of vaporization that accounts for lateral expansion in the case of experimental data for the effect of laser pulse parameters on recoil momenta. The use of a sliding focus increased the maximum velocities of the accelerated particles by a factor of 1.5-2.5. Particles of millimeter dimensions were accelerated to maximum velocities of $4 \cdot 10^5$ cm/s by a giant pulse with energy of 130 J and duration of 5 μs with a sliding focus. Figures 7, references 26: 19 Russian, 7 Western.
[182-6610]

ACCELERATION OF CHARGED PARTICLES IN SHEAR FLOWS OF COSMIC PLASMA

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian
Vol 33, No 8, 20 Apr 81 pp 416-419 manuscript received 12 Mar 81

BEREZHKO, Ye. G., Institute of Space Research and Aeronomy, Siberian Department, USSR Academy of Sciences

[Abstract] Although various mechanisms such as the Fermi mechanism and the regular mechanism of acceleration on shock waves propagating in a collisionless plasma as well as several others can explain the conversion of large-scale plasma motion to the energy of individual charged particles, there are some experimental results that cannot be attributed to any of these mechanisms. For example when satellites cross the boundary of the earth's magnetosphere they register constant fluxes of high-energy electrons with a power-law spectrum in the energy region beyond about 18 keV. The author considers a new mechanism of charged particle acceleration that can explain these results. The analysis is based on a model of idealized two-dimensional shear flow of a collisionless plasma in which inhomogeneities of the magnetic field act as scattering centers. The law of energy behavior of a particle moving in the medium with a velocity much greater than the hydrodynamic velocity of the plasma with scattering by inhomogeneities is derived by representing this motion in the form of fluctuations between two scattering centers with appropriate averaging over all possible pairs. It is shown that this mechanism can account for acceleration of charged particles in shear flows of a collisionless plasma, and that the rate of energy accumulation is proportional to the square of the curl of the hydrodynamic velocity of the plasma. The proposed mechanism is widely applicable in view of the frequent occurrence of plasma shear flows in outer space. The most typical example for interplanetary space is high-velocity fluxes of charged particles in the solar wind, in particular in the layer on the boundary of the earth's magnetosphere. Thus the process of acceleration of charged particles in shear flows may be important in the formation of nonthermal particle spectra, and in particular cosmic rays. Figure 1, references 4 Russian.
[184-6610]

UDC 621.316.5:537.529

NUMERICAL MODELING OF A LAMINAR PULSE DISCHARGE

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 4, Apr 81 pp 678-686
manuscript received 19 Feb 80, after revision 26 Aug 80

ROMANOV, G. S. and SMETANNIKOV, A. S., Scientific Research Institute of Applied Physics Problems at Belorussian State University imeni V. I. Lenin

[Abstract] The processes that arise in electric explosion of cylindrical foils, i. e. in a laminar pulsed discharge, are analyzed on the basis of a numerical experiment. This process is characterized by quite uniform and stable lengthwise distribution of discharge parameters. The modeling is based on magnetogasdynamic

methods of calculation. It is assumed that a capacitor bank is discharged into a cylindrical foil of given radius and thickness. The current flowing through the foil results in heating, melting, vaporization and dispersal into the ambient space. The analysis is based on a system of homogeneous magnetogasdynamic equations, and boundary conditions on the foil surface assigned by simultaneous solution of Maxwell's equations and the electrical engineering equations of the external circuit. The system of magnetogasdynamic equations is solved by a totally conservative difference scheme, and an implicit difference scheme is used to solve the Maxwell's equations and the electrical engineering equations. Calculations are done for an aluminum foil in air. The numerical analysis accounts for the jump in conductivity of the metal as density falls from the solid-state value to the gas density. The presence of condensed phase and vapors is taken into consideration. The authors discuss time development and dynamic behavior of gasdynamic, electrical and kinetic parameters of the explosion. The proposed model is found to be basically correct and in agreement with experiment despite the lack of important data on conductivity and equations of state of aluminum. Loss of metallic conductivity is shown to be due to processes in the body of the conductor rather than to surface effects. The calculations show radial asymmetry of parameters in the plasma layer. Edge effects due to finite length of the cylinder are insignificant. Figures 6, references 24: 23 Russian, 1 Western.
[199-6610]

UDC 537.523.74

LUMINESCENCE WAVES IN A PULSATING DISCHARGE

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 4, Apr 81 pp 706-713 manuscript received 1 Aug 78, after revision 11 Apr 80

CHUTOV, Yu. I., REMNEVA, T. Ye. and KRAVCHENKO, A. I., Kiev State University imeni T. G. Shevchenko

[Abstract] Detailed studies are done on luminescence waves in a pulsating discharge in dielectric cells for a wide range of parameters. The discharge was set up in a cylindrical glass cell 50 mm in diameter and 5 mm high with flat faces 5 mm thick separating the metal electrodes from the gas-filled interior of the cell. The glass had a dielectric constant of 7. The cell could be filled with inert gases or mixtures of gases at different pressures. The pulsating discharges were excited by square-wave voltage. The maximum amplitude of the supply voltage was 1200 V, pulse duration was 10 μs, and recurrence rate was 500 Hz. The instrumentation enabled registration of the current pulses of the pulsating discharge and the quantity of electricity transferred in the external circuit of the discharge. Gas fillers were neon, argon, krypton or a neon-argon mixture at pressures of 10-150 mm Hg. Measurements of the characteristics of propogation of luminescence waves showed that the velocity of propagation varies from 10^5 to $2\cdot10^6$ cm/s, and is linearly dependent on the current density in the external circuit regardless of the method of current variation. The properties of the ionization wave in a pulsating discharge are analyzed on the basis of Townsend avalanches, and it is shown that the experimentally observed luminescence waves correspond to

ionization waves. Based on this correspondence, the maximum concentration of charged particles in the discharge is estimated to range from $4 \cdot 10^9$ to $1.2 \cdot 10^{10}$ cm^{-3} for various conditions. Figures 5, references 10: 5 Russian, 5 Western.
[199-6610]

UDC 533.9.07

PARAMETERS OF A DENSE PLASMA IN A PULSED PLASMA ACCELERATOR

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 4, Apr 81 pp 714-718 manuscript received 26 Jan 79

ALEKSEYEV, A. M. and TSVETKOV, Ye. P., State Scientific Research and Design Institute of the Nitrogen Industry and Organic Synthesis Products, Moscow

[Abstract] Dense plasma parameters are experimentally studied on a plasma accelerator with capacitive energy store utilizing IM-5-140 capacitors with total capacitance of 2640 μF. Charge voltages ranged from 0.1 to 5.0 kV. The gas-tight chamber of the accelerator was filled with air at normal pressure. The electrodes were plates 10 cm wide and 20 cm long. The chamber had a volume of 8000 cm^3. Since streak camera photos have shown that each half-period of the current discharge has its own plasma formation, only the parameters of the first plasmoid were studied. An investigation was made of the electric discharge current, plasma movement, the pressure and the brightness temperature of the plasma. It is shown that plasma motion under the given experimental conditions is analogous at currents of 50-500 kA to a detonation wave. Figures 3, references 13: 9 Russian, 4 Western.
[199-6610]

KINETIC THEORY OF PLASMA EQUILIBRIUM IN AN ELECTROMAGNETIC FIELD

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 80, No 4, Apr 81 pp 1383-1390 manuscript received 7 Aug 80

GORBUNOV, L. M., GRADOV, O. M., ZYUNDER, D. and RAMAZASHVILI, R. R., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] An analysis is made [illegible].sma equilibrium based on the assumption that particles leaving the plasma have maxwellian distribution. A linearly polarized electromagnetic wave of given frequency is incident on the plasma. The vector of electric field strength in the wave is directed along the x-axis and depends only on the z coordinate. Equilibrium states are considered in which the wave is reflected from the plasma, and the wave field damps out in the region of positive z, and has the structure of a standing wave in the region of negative z. Equations are derived for the behavior of the rf electric field and the charge separation field. A quasineutrality approximation is proposed, conditions of equilibrium are defined, and the equilibrium state is analyzed. The spatial distribution of fields, density and flow velocity is studied. It is shown that the equilibrium state is possible only for a certain relation between the amplitude of the incident wave and the concentration of particles leaving the plasma. In this connection, the particle concentration is nowhere equal to zero, plasma flow is directional, and a constant current flows in the plasma. The given state can be realized only under conditions where the current flowing through the plasma is closed to the plasma source. Figures 4, references 9: 6 Russian, 3 Western. [187-6610]

UDC 537.531

CHARACTERISTICS OF LINE EMISSION OF A BEAM-PLASMA DISCHARGE WITHOUT ELECTRIC FIELD

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 5, May 81 pp 1015-1017 manuscript received 4 Apr 80

BUSYGIN, E. P., GRIGOR'YANTS, V. G., LUGOVSKOY, A. V. and POPOVICH, V. P., Institute of Crystallography, USSR Academy of Sciences, Moscow

[Abstract] Previous research has shown that the optical emission of a beam-plasma discharge and the polarization of this emission may provide information on the spatial structure of the rf fields generated when an electron beam interacts with a plasma. This paper gives results of a study of local parameters (intensity and degree of polarization) of line emission of a helium beam-plasma discharge produced in the absence of a magnetic field with injection of both continuous and velocity-modulated electron beams into a gas volume. An electron beam with current of 55-60 mA and voltage of 2.3-2.5 kV was injected into a glass flask 150 mm in diameter and 300 mm long filled with helium to a pressure of about 0.01 mm Hg. Velocity modulation of 0.5-1% in the frequency range of 400-1500 MHz was by a microwave oscillator. Emission on the axis of the discharge was focused on the slit of an ISP-51 spectrograph and photoelectrically recorded in the dc mode with time constant of about 2-5 s, which is several orders of magnitude longer than the characteristic times of the beam-plasma discharge. Axial distribution of intensity was measured with resolution of 0.5 cm in a region 25 cm long situated 7.5 cm away from the plane of beam injection. A rotating analyzer in the form of a dichroic film was used for alternately measuring the intensity distributions of radiation components polarized parallel and transverse to the discharge axis. It was found that the beam-plasma discharge is maintained by powerful plasma oscillations produced upon interaction with the injected beam. The frequency of these oscillations is much greater than the frequency of collisions of an electron with helium atoms. The intensity of plasma oscillations is a nonmonotonic function of beam length. It is shown that in a weak field, electrons may acquire sufficient energy to excite and ionize helium atoms if the kinetic energy of a free electron surpasses a certain average threshold. It is concluded from an analysis of the results that the maximum line intensity is shifted relative to the maximum field, and that the maximum degree of ionization should correspond to the region of space with maximum intensity of the longitudinal field component. The displacement shows the redistribution of charged particles due to inhomogeneity

of the rf field. Near the intensity maximum the optical radiation is practically unpolarized, and consequently the collisional mechanism of electron acceleration typical of a classical rf discharge predominates in this region. Figures 2, references 6: 5 Russian, 1 Western.
[204-6610]

UDC 533.9:629.78

ELECTRON BEAM OF FINITE DURATION IN PLASMA

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA: MATEMATIKA, MEKHANIKA, ASTRONOMIYA in Russian No 7, Issue 2, Apr 81 pp 121-123 manuscript received 7 Dec 79

KHAZIAKHMETOVA, T. Kh.

[Abstract] A possible model has been proposed for describing the injection of a "cold" relativistic electron beam of low density and finite duration into a "cold" plasma [see A. A. Rukhadze, V. G. Rukhlin, ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, Vol 61, 1971, pp 177-189]. The problem reduces to solution of Maxwell's equations for given charge density and current density of the beams and known plasma parameters described by a permittivity tensor. This model was later used as a basis for studying the influence that the shape of the beam density profile has on magnetic and charge neutralization. The author of this article uses the same formulation to study the influence that the shape of the density profile of the electron beam has on the fields and currents induced in the plasma behind the beam. Short and long beams are considered in the asymptotic limit of large values of the time and coordinate where all transient processes are damped, and the induced fields and currents become functions $z_1 = z - ut$ and $z_2 = z_1 + u\tau$, z_1 is the distance from the leading edge of the beam (from the plane $z = ut$) to observation point z at time t, z_2 is the distance from the trailing edge of the beam (from the plane $z = u(t - \tau)$), and τ is the time of beam injection. At a given time t, the beam is in the region $u(t - \tau) \leq z \leq ut$. Beams with four charge density profiles are considered: 1. radially and longitudinally homogeneous; 2. radially uniform with longitudinally increasing charge density, 3. radially uniform with longitudinally decreasing charge density; 4. radially uniform with sinusoidal longitudinal profile. It is shown that in the case of short beams ($\tau\nu \ll 1$, where ν is the frequency of collisions between electrons in the plasma), the charge density for the fourth beam oscillates with amplitude much lower than that for the first three beams. Transverse perturbations for the third and fourth beams are small compared with the first two beams. For long beams, perturbations of all types are smaller for the third and fourth beams, and at great distances the perturbations for all beams are equal. References 2 Russian.
[208-6610]

UDC 535.241.6

SPECTRAL STUDIES OF THE PLASMA OF A PULSED LIGHT SOURCE BASED ON A REFLECTED z-PINCH

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 5, May 81 pp 787-793
manuscript received 16 Jul 80

BELOGOLOVTSEV, G. I.

[Abstract] In developing and designing a cavity-type light source for flash photolysis [G. I. Belogolovtsev et al., TEPLOFIZIKA VYSOKIKH TEMPERATURE, No 2, 1980, p 418], it was found that a cumulative increase in the concentration and temperature of the gas discharge plasma may occur not only in z-pinches, but also upon collision between the compressed cylindrical plasma shell and the quartz wall. At argon pressures of 0.1-1.0 mm Hg the plasma shell compression is shock wave motion. In the cavity-type lamp the convergent shock wave is strongly decelerated as it strikes the inner quartz tube coaxial with the discharge chamber. In the case of a strongly skinned pinch discharge, the plasma moving along the shock wave front forms a reflected shock wave under the action of pondermotive forces. The heated and pinched plasma of the reflected shock wave produces strong radiation. Electrodynamic formation of intense light pulses with steep trailing edges is observed for the reflected z-pinch just as for a linear z-pinch: when the argon pressure is optimum for the given energy accumulator and a lamp of given geometry, discharge compression occurs only once. In this case, the phase of the maximum compression should be shifted by 140-170° relative to the discharge current. The author continues his investigation of the reflected z-pinch effect in this paper, giving the results of experimental research done on the IIS-5 facility with differing energy accumulators, and also the results of spectral studies of a reflected z-pinch plasma. The main components of the IIS-5 cavity light source are the annular discharge chamber bounded by coaxial quartz cylinders with diameters of 150 and 38 mm and length of 740 mm, a commutating planar vacuum discharger and a bank of IK-25-12 capacitors. The plasma parameters of the reflected z-pinch were determined by electrical measurements and high-speed photography. Oscilloscope signals were taken from an FEU-18A photomultiplier with UFA-1 light filter. The energy of the light pulse was measured with the IMO-2M calorimeter. Time-scan spectra were produced by a spectrochronograph consisting of the prism component of the ISP-51 spectrograph and a high-speed SFR-1M camera. The EV-39 brightness standard was used to get the densitometric curve of the photographic film. It is shown that the Spitzer formula is suitable for evaluating the parameters of electronic equipment with a reflected z-pinch. In the case of a strongly skinned z-pinch with continuous return conduction, photochronograms can be used to determine the electron concentration of the plasma, assuming that all the gas is entrained in the pinch. The emission spectrum of a cavity source is studied for flash photolysis in the visible and ultraviolet spectral ranges. Figures 3, rrferences 12: 11 Russian, 1 Western.
[205-6610]

STRESS, STRAIN AND DEFORMATION

UDC 621.378.325

INVESTIGATION OF TEMPERATURE PECULIARITIES OF OPTICAL BREAKDOWN OF GLASSES

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 5, May 81 pp 965-969
manuscript received 24 Dec 79, after revision 15 Mar 80

BEBCHUK, A. S., KOLDUNOV, M. F., ULANOV, S. F. and KHAPLANOVA, N. Ye.

[Abstract] According to current concepts, the major effects responsible for optical breakdown of solid transparent dielectrics are electron avalanche due to impact ionization of the lattice or thermal instability due to absorption of radiation on small absorbing inclusions and inhomogeneities. However, theoretical and experimental research on these phenomena up until now has dealt mainly with crystalline dielectrics. To get experimental results for amorphous substances as a basis for comparison with experimental data and the analogous dependences for crystals, the authors study the temperature dependences of thresholds of optical breakdown and the particulars of destruction of K8, TK16, TF5 and TF10 glasses from 20°C to the softening point. The source of radiation was a monopulse ruby laser with passive Q-switching. Spacial steps were taken to produce a smooth bell-shaped pulse of single-mode radiation with half-amplitude duration of 12 ns. The laser output was focused at a depth of 1.5 mm inside the specimen by a microscope objective. The peculiarities of breakdown were studied by high-speed photomicrography. Curves were plotted for the distribution of the probability of a laser spark as a function of the radiation intensity at the center of the caustic, and also the probability distribution for microscopically observable destruction in the vicinity of the caustic. Accordingly, two different quantities are defined: the spark breakdown threshold W_S, and the "residual" destruction breakdown threshold W_D. W_S is understood to mean the peak intensity of radiation in the center of the caustic where the probability of a spark is equal to 0.5. Analogously, W_D is the peak intensity where the probability of a macroscopic destruction is 0.5. The results show a separation of the spark threshold and the residual destruction threshold at temperatures close to the softening point in TF glasses. It is experimentally shown that there may be a plasma accompanying optical breakdown of glasses without macroscopic descruction. Figures 3, references 15: 14 Russian, 1 Western.
[204-6610]

THEORETICAL PHYSICS

UDC 537.8.029.6

DIFFRACTION OF ELECTROMAGNETIC WAVES BY A CYLINDER OF ARBITRARY PROFILE THAT CONTAINS A SYSTEM OF CURVED SHIELDS

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 4, Apr 81 pp 61-65 manuscript received 2 Aug 80

PANASYUK, V. V., academician, UkSSR Academy of Sciences, SAVRUK, M. P. and NAZARCHUK, Z. T., Physicomechanical Institute, UkSSR Academy of Sciences

[Abstract] The authors consider the plane problem of diffraction of E-polarized or H-polarized electromagnetic waves by a cylinder of arbitrary profile containing a finite number of ideally conductive infinitely thin curved cylindrical open shields with arbitrary placement. The steady-state two-dimensional diffraction problem is reduced to solution of systems of integral equations in the case of E-polarization, or integrodifferential equations in the H-polarized case. These systems are numerically solved by direct methods. Computational results are given for field amplitudes and for amplitude diagrams of the scattered field in the case of incidence of a plane wave on an elliptical cylinder with and without a single rectilinear shield. The latter case shows good agreement with the data in the literature. Figures 2, references 9: 7 Russian, 2 Western.
[190-6610]

UDC 517.9:53

SOLUTION OF DIFFRACTION PROBLEMS INVOLVING BOUNDED SHIELDS WITH CIRCULAR AND RECTILINEAR SLOTS

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 4, Apr 81 pp 69-71 manuscript received 29 Aug 80

SHCHERBAK, V. V., Institute of Radio Physics and Electronics, UkSSR Academy of Sciences

[Abstract] The author considers the problem of scattering of scalar waves by a thin hard or soft disk containing M-1 concentric slots in plane $z = 0$. The wave number K and the distances a_j ($j = 1, 2, \ldots, M$) of the edges of the slots

and the disk from the center of symmetry are taken as arbitrary. Computationally efficient rigorous solutions of diffraction problems are found for a disk with circular slots and for a thin strip with 2M-2 symmetrically arranged straight infinite slots, as well as for more complex structures. A method of formulation is proposed that enables reduction of the solution of these problems of diffraction theory to an infinite system of linear algebraic equations with rapidly damped coefficients of simple form. The proposed method of solution can be generalized to analysis of vector problems of diffraction, and to the case of an infinite number of periodically configured disks or strips. References 4 Russian.
[190-6610]

UDC 519.677

USE OF SPLINES IN NUMERICAL SOLUTION OF AN INTEGRAL EQUATION OF THE PROBLEM OF SIGNAL RECONSTRUCTION

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 4, Apr 81 pp 72-75 manuscript received 17 Sep 80

VERLAN', A. F., ABDUSATAROV, B. B. and BILENKO, V. I., Institute of Electrodynamics, UkSSR Academy of Sciences

[Abstract] An integral equation of a signal reconstruction problem is considered in which the experimental origin of the transfer functions necessitates numerical differentiation. The methods of interpolational polynomial splines are applied to construction of an algorithm for approximate solution of the problem. It is shown that this method is suitable for computer application with a cubic spline approximation of the transient response. Errors are estimated with consideration of the trapezoidal rule and rounding errors. References 6: 5 Russian, 1 Western.
[190-6610]

UDC 519.21

PROBABILITIES OF LARGE DEVIATIONS FOR MAXIMUM LIKELIHOOD ESTIMATES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 257, No 5, 1981 pp 1048-1052 manuscript received 4 Nov 80

IBRAGIMOV, I. A. and RADAVICHYUS, M. E., Leningrad Department of the Mathematics Institute imeni V. A. Steklov, USSR Academy of Sciences

[Abstract] Expressions are found for probabilities of large deviations in the following problem of maximum likelihood estimates. Let $X_1, X_2, \ldots, X_n$ be a sample of volume n, where independent observations X_j take on values in measurable space $(\mathfrak{X}, \mathfrak{A})$, where they have the probability density function $p(x; \theta)$ with respect to σ-finite measure ν. The unknown parameter θ belongs to the convex open

bounded set Θ, a subset of R^k. It is assumed that the experiment generated by observations X_j is regular. In particular the Fisher information matrix $I(\theta)$ is defined. It is further assumed that for all x, lm $p(x; \theta)$ is doubly continuously differentiable with respect to θ and for any K and positive δ,

$$\sup_{\theta\in K} |I^{-1}(\theta)| = \sup_{\theta\in K} \sup_{|x|=1} (I^{-1}(\theta)x, x) < \infty,$$

$$\inf_{\theta\in K} \inf_{\{h:\, \theta+h\in\Theta,\, |h|>\delta\}} \int_{\mathfrak{X}} (p^{1/2}(x;\ \theta+h) - p^{1/2}(x;\theta))^2 \nu(dx) > 0.$$

Here K is an arbitrary compact subset of . References 2 Russian.
[198-6610]

SELF-FOCUSING AND ABSORPTION OF THE ENERGY OF A LASER BEAM IN AN INHOMOGENEOUS PLASMA

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian
Vol 33, No 9, 5 May 81 pp 451-454 manuscript received 23 Mar 81

YEROKHIN, N. S., MOISEYEV, S. S., MUKHIN, V. V., NOVIKOV, V. Ye. and SAGDEYEV, R. Z., Physicotechnical Institute, UkSSR Academy of Sciences

[Abstract] There are three competing processes responsible for absorption of the energy of a laser beam in the plasma corona of a target: Coulomb collisions, linear transformation of an obliquely incident transverse wave to a longitudinal wave, and parametric mechanisms. Until now the experimental data on this problem have been mostly ambiguous because they lie in the boundary region between all these processes due to the limitations on attainable experimental parameters. This paper is devoted to a theoretical analysis of laser beam propagation in plasma and energy absorption in the transition region. It is shown that when the transverse dimensions of the beam are small enough, it may penetrate into the region of opacity to a depth that exceeds this dimension. It is assumed that a three-dimensional axisymmetric wave beam of TM type is normally incident on a plasma with linear density profile. A solution is found for the standard wave equation for the H_x component of the magnetic field. An analysis of the relation between the above-mentioned competing processes shows that there is a shift toward an increasing contribution from the collisional mechanism at moderately high intensities of laser energy. Figure 1, references 6 Russian.
[200-6610]

THERMODYNAMICS

UDC 536.24

RADIATIVE-CONDUCTIVE HEAT TRANSFER IN A PLANE LAYER OF WEAKLY ABSORBING MEDIUM

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATURE in Russian Vol 19, No 2, Mar-Apr 81 pp 352-361 manuscript received 29 Dec 79

STEPANOV, S. V. and BITYUKOV, V. K., Institute of High Temperatures, USSR Academy of Sciences

[Abstract] Previous research on the problems of radiative heat transfer in a planar layer of weakly absorbing medium has yielded relations that give the correct asymptotic solution of the problem as $\tau = kH \to 0$ in the first order with respect to τ, where k is the coefficient of absorption, and H is the thickness of the layer. Here the authors consider the analogous problem for the case of radiative-conductive heat transfer in a planar layer of non-dissipative medium with opaque mirror-reflection boundaries with given temperatures. It is shown that radiant and conductive fluxes begin to interact, bringing about an increase in the overall energy flux in weakly absorbing media, even in the first order with respect to τ. Estimates are given for the residual terms in the expressions found for temperature and radiant flux. Comparison of analytical and numberical results with data in the literature shows satisfactory agreement. Figure 1, references 15: 9 Russian, 6 Western.

[180-6610]

UDC 536.24

OPTIMIZATION OF THERMOPHYSICAL CALCULATIONS. 1. STRATEGY OF USING NONLINEAR PROGRAMMING METHODS IN CALCULATING THE THERMODYNAMIC PROPERTIES OF MIXTURES

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 40, No 5, May 81 pp 922-923 manuscript received 22 May 80

LABINOV, S. D., ZRYAKOV, I. N. and SHELOMENTSEV, A. M.

[Abstract of paper deposited at the All-Union Institute of Scientific and Technical Information, registration number 4845-80 Dep.]

[Abstract] Methods based on the principle of corresponding states are the most promising for calculating the thermophysical properties of complex systems like

mixtures. In application of this approach to individual substances, it is sufficient to know the critical parameters (temperature T_c and pressure p_c) and also the parameter A. These parameters can be corrected by using experimental data on the properties of the substances in the investigated temperature and pressure range. Optimization in calculating the thermodynamic properties of mixtures essentially involves correction of the parameters of the individual components from experimental data with subsequent application of the optimized parameters in the rules of combination for pseudocritical parameters of the mixtures. The described approach is a special case of the method of modeling multicomponent mixtures. The distinguishing feature of the technique is direct modeling of the parameters of a mixture rather than the properties themselves. By way of illustration, the parameters of methane, ethane, propane and nitrogen are optimized. Nonlinear programming methods are used to find the optimum parameters. The discrepancy with experimental data is reduced by using the optimum parameters of individual components in calculating the properties of mixtures. References 9. [206-6610]

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